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ACTIVITY AND DISTRIBUTION OF CERTAIN WILD MICE IN RELATION TO BIOTIC COMMUNITIES[1]

BY M. S. JOHNSON

I. INTRODUCTION

A few animals may be worldwide in their distribution, and others may be limited to a single region or even to a small area. Similarly, certain animals may occur continuously throughout their range, and others may be closely restricted in their local habitats. It often happens that similar and related species are distributed over the same area, yet do not mingle because they are confined to different habitats.

An especially striking case of such a definite limitation of territory is that of the forest and the prairie deer mice, *Peromyscus leucopus noveboracensis* (Fischer), and *Peromyscus maniculatus bairdii* (Hoy and Kennicott). These two species are similar in appearance, and occur in the same general localities over a wide area, yet in their local distribution they are restricted as their names suggest.

Various theories have been offered to explain the distribution of different mice in different kinds of situations. Chenoweth (1917) conducted experiments which seemed to show that forest deer mice avoid conditions of high evaporation rate, whether the evaporation is due to dry, or warm, or moving, air. He suggested that the forest deer mice "apparently avoid the higher rates of evaporation by staying in the forest." Dice (1922) found there were no differences between

[1] Contribution from the Zoological Laboratories of the University of Illinois, No. 288.

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the species in food or water requirements, or toleration of temperature extremes, and he said that the restriction of range was not due to any physical inability of either species to live in the habitat of the other. Wood (1910) said the burrows of the forest species were always under logs, and suggested that this might explain the limits of distribution.

It is the purpose of the present paper to show that all explanations which assume that the distribution of the mice is controlled by any single factor of the physical environment are inadequate; and to show that the distribution of the mice is rather dependent on their relations to the whole biotic community or type of community of which they are members.

II. RHYTHMIC ACTIVITY

The innate behavior of animals furnishes a basis for their relation to the physical factors of their environment, determining to what factors the animal shall respond, and what the response shall be. The time at which the animals are active has an important relation to all the rest of their behavior, which is conditioned chiefly by the environmental complex prevailing during the active period. Accordingly, a special study has been made of the time of activity and the conditions controlling it in the case of the two local species of deer mice, with particular reference to the forest deer mouse.

1. Care of mice in captivity

The mice used for experimental work were caught alive in box traps and brought to the laboratory, where they were usually placed in wire screen cages of one-fourth-inch mesh. The cages were 9 x 10 x 14 inches. Usually the mice were kept in pairs, but there might be from one to four or more mice in a cage. Most of the mice were kept in the greenhouse, except as they were being used over periods of time in darkroom or attic for activity experiments. Of the greenhouse mice, some were in a section which was artificially heated to room temperature during cold weather, and the others were in a more exposed section subject to outdoor temperatures.

The mice were given cotton and tissue paper for nest-making; and also in some cases wooden nest-boxes of convenient size (4 x 4 x 5 inches), with a small side-opening for the entrance and exit of the mice, and a removable cover to permit of examination of the nest. Water was supplied usually by the drop method; but in some cases, and particularly in the outdoor cages where freezing was likely, the water was given

in open dishes. The principal food for all the mice was whole wheat, but the attempt was made to supply a sufficient variety of food so the mice would not lack any dietary essential. Salted peanuts were given frequently, but sparingly. The writer has found, as did Dice (1922), that on a diet of grain without peanuts the mice seem to be lacking something and are inclined to cannibalism. If peanuts are given to excess, however, the mice eat them instead of other food, and may die. Either milk or lettuce was given every few days, to insure a plentiful supply of vitamins.

2. Ordinary rhythm of activity

A number of writers, in referring to the forest and the prairie deer mice, have said that they were nocturnal (e.g., Sumner and Swarth, 1924). It is well-known that house mice may be active both day and night, though they are more likely to be active at night; there seem to have been no definite published records of the activity of house mice, however. Meadow-voles are described (Lantz, 1907) as being diurnal as well as nocturnal.

No detailed study has been reported of the time of activity of any wild mammal. It has been shown (Nicholls, 1922) that the guinea-pig is active almost continuously, and lacks both diurnal and nocturnal rhythm. The activity of rats has been studied extensively by various authors. Richter (1922) made studies of time of activity of albino rats, but in all other studies with rats the object has been to determine the amount of activity rather than the time of activity. The amount of activity of rats has been studied as it is affected by age (Slonaker, 1907, 1912), diet (Slonaker, 1912a; Stewart, 1898), adrenal products (Durant, 1924), and sexual phenomena (Slonaker, 1924, 1925; Wang, 1923, 1924), but little attention has been paid to the time of day during which the animals are active other than to say that the rats have nocturnal habits.

In the present experiments, which were concerned with time of activity, the mice were kept in cages supported by strong rubber bands. The point of an indicator attached to the cage traced the movements of the cage on a paper disk turned by clock-work, and so made a record of the time of activity of the mice in the cage. The paper disk was turned by the works of an alarm clock, making a complete rotation once in twelve hours. In some cases the records were made by a recording pen on white paper, and in some cases by a pinpoint on smoked paper.

When the mouse tested was quiet, the record showed a smooth curved line; when the mouse was active, the record showed irregularities at the

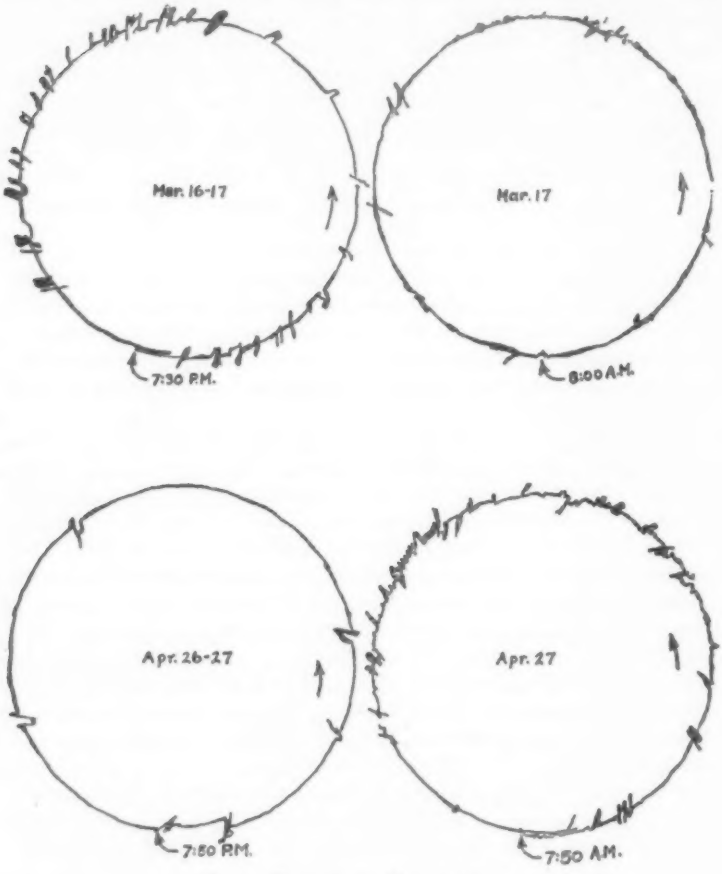

FIG. 1. TRACING OF MOUSE ACTIVITY

time of activity. After a smoked record had been labeled and dated, it was made permanent by being dipped in dilute shellac. In figure 1, tracings of such records are shown.

By apparatus of the type described, numerous records have been obtained of the time of activity of forest deer mice in captivity at the Vivarium Building; it has been found very generally true that the deer

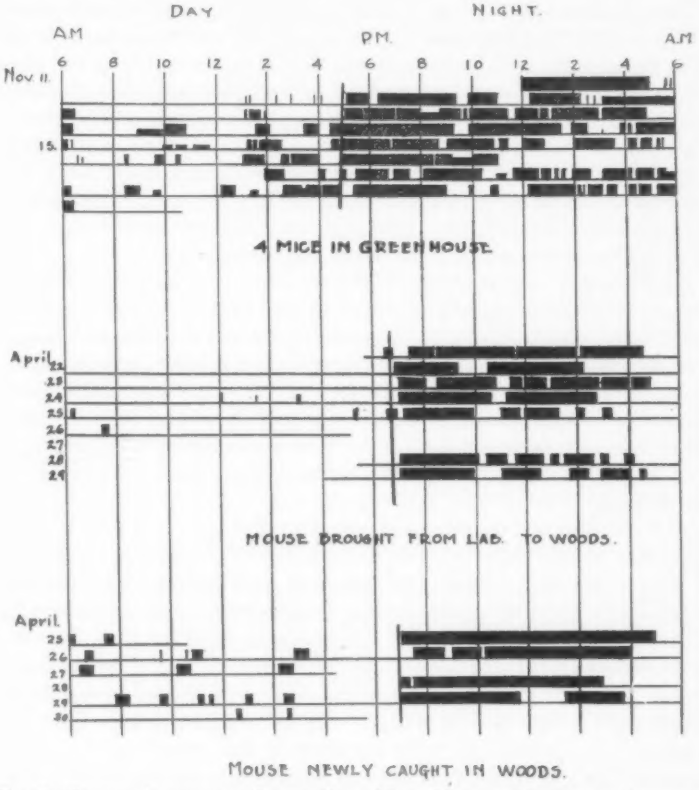

FIG. 2. NORMAL ACTIVITY OF FOREST DEER MICE, SHOWING NOCTURNAL ACTIVITY AND CHANGES WITH SEASONS. UPRIGHT LINE MARKS TIME OF SUNSET

mice are active from dark until daylight, and quiet from daylight to dark. This seemed to hold true whether or not it happened that the mice were disturbed at regular or irregular intervals for the purpose of changing the records or for other reasons.

In order to make doubly certain that this periodicity in activity of the mice was natural and normal to them, and had not been produced by some uncontrolled factor in their laboratory environment, a series of activity records was made at the University Woods under as near to natural conditions as could be produced. Data were obtained from a mouse which had been kept in the laboratory and taken back to the woods, and also from another mouse caught in the woods at the time. In each case the cage was suspended very near the ground, in a situation sheltered by a large log; and in the cage was placed a considerable quantity of dead leaves and rotten wood, so the mouse could remain entirely concealed if it wished. Records were obtained for more than a week. They showed, for both mice, activity differing in no respect from that observed under laboratory conditions. There was fairly constant activity at night, and nearly continuous quiet during the day. The time when activity began and ceased agreed very closely with the time of arrival of darkness and light, as may be seen from figure 2. In this figure, periods of activity are shown by blocks of black, and periods of quiet by single lines. The heavy vertical line shows time of sunset. A study of the figure shows a relation between the seasons and time of activity. In the winter, when the days are short and the nights are long, the daily period of quiet is shorter and of activity is longer.

Records of activity of the prairie deer mouse are similar to those of the forest species.

3. Continuation of rhythm in continuous darkness

As has been stated above, the periods of quiet and activity of the deer mouse were found to correspond to periods of light and darkness. To determine whether the observed daily rhythm was dependent on the difference in light by day and night, a forest deer mouse for which a series of records of normal activity had already been secured was placed in an activity cage in a darkroom. For more than a month it saw no light except the dim light of a flashlight as the records on the clocks were changed, or as the food dish or water bottle was refilled. Yet at the end of that time the records showed as definite a relation between mouse activity and outside light as at the beginning. Moreover, there was no day during the intervening period when the same relation between time and activity did not hold true. This is shown in the first part of figure 3.

No daily change in environmental factors could be an explanation of this periodicity of activity. The temperature was practically con-

stant at seventy degrees Fahrenheit (twenty-one degrees Centigrade). Neither temperature nor humidity showed daily fluctuations. The darkroom adjoined a research laboratory, and sounds carried well through the wall; but sounds from the laboratory, if they had any influence at all on mouse activity, could have had only a disturbing rather than a regulating effect. The time at which the records were changed was purposely made so varied that it could have had no tendency toward producing a rhythm of activity.

In July, 1924, three forest deer mice were placed in activity cages in the darkroom. A male and a female were together in one cage, and a male alone was in another cage beside the first. These mice were kept in continuous darkness, except that a single electric light was turned on when it was necessary to enter the darkroom. Activity records for both cages had been taken for a number of days when the mice were first placed in the darkroom. During November another series of activity records was taken. In the cage with the pair were two young males, born about October 15. The activity of these four (the pair of adults and their young) in November still showed a marked daily periodicity of activity, but the time of activity no longer corresponded to the time of darkness outside. The time of activity of the male in a cage alone corresponded to that of the mice in the adjoining cage, and likewise no longer corresponded to the time of darkness outside. A newly caught female was then put in the cage with the male. The times of activity of this pair continued the same as the time of activity of the male alone. The time of activity of the female was evidently adjusted to correspond to the time of activity of the male.

The original pair, after being separated from their young, were subsequently transferred to another darkroom. Here, more than seven months after the mice could last have been influenced by daily variations in light, activity records still showed a pronounced daily periodicity of activity. As in the case of the records taken in November, these records showed no correspondence between time of activity and time of outside darkness. The taking of further records was unfortunately prevented by the escape of the mice, but there seems no reason to doubt that the pronounced daily periodicity of activity in continuous darkness would have continued longer, and perhaps indefinitely.

4. Activity of mice born in darkroom

The birth of a litter of forest deer mice in the darkroom gave opportunity to study the time of activity of mice which had never seen day-

light and had never experienced a daily alternation of light and darkness. At the age of about six weeks these young mice were separated from their parents, although kept in nearby cages in the same darkroom, and records of their activity taken. Records had already been taken of the cage containing both parents and young. The records showed, for the young separated from their parents, a periodicity of activity similar to that of the adults. That is, there was a well-defined twenty-four-hour rhythm, and the time of activity is the same as that of the parents and does not correspond with periods of darkness outside. Possibly the mice have an innate tendency to an activity rhythm.

5. Experimental modification of rhythm

a. Light. It has been shown that the rhythm of activity of the forest deer mouse is not dependent for its maintenance on the daily alternation of light and darkness. This fact does not necessarily imply, however, that the periodicity of activity may not be influenced by light. Therefore experiments were conducted with animals of this species to determine the influence of light on the time of activity, and the influence of light on the twenty-four-hour periodicity of activity.

The procedure in the study of the effect of light upon the time of activity was to subject a mouse in the darkroom to light from a blue-bulb "daylight" thousand-watt electric lamp. The light was used from eight in the evening until eight in the morning. The lamp was about three feet obliquely above the cage. Water was run beneath the cage to prevent the possibility of overheating. When the light was being used the temperature rose from twenty-one degrees Centigrade to twenty-five or twenty-eight degrees. The mouse used was one which had already been kept about a month in the darkroom and still maintained its original rhythm of activity. Under this condition of light at night and darkness in the daytime, the mouse became quiet at night and active in the daytime. The change in the behavior of the mouse was gradual, but it was complete. Although the animal might now move about somewhat at night, this was no more than it had previously done in the daytime. After twelve days of this artificially produced day and night, and after the periods of quiet and activity of the mouse were adjusted to these new conditions, the use of the light was discontinued. Once more in continuous darkness, the mouse continued to be quiet at night (as it had been when the light was burned at night), and to be active in the daytime (as it had when that period was the

only part of the twenty-four-hour cycle that was dark). Figure 3 shows graphically the activity of the mouse for a period before and

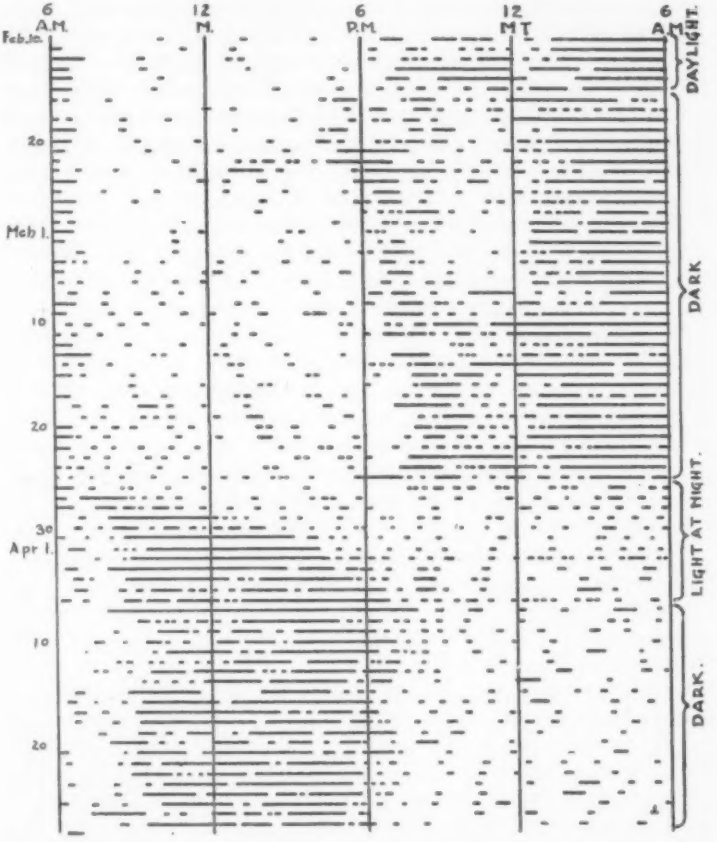

FIG. 3. ACTIVITY IN A DARK ROOM SHOWING PERSISTENCE AND REVERSAL OF RHYTHM

during its stay in the darkroom. The dots represent sporadic or intermittent activity; the lines represent nearly continuous activity. In a few cases the record for a part of a twelve-hour period was missing, due

to such accidents as the recording pen running dry, or the paper record becoming detached from the rotating metal disk. In such cases the activity for the missing period has been interpolated in the figure as the mean of the activity at the corresponding time on the day preceding and following. It is felt that no serious error is introduced in this way. Figure 1 shows tracings of the original records of activity for two of the days that the mouse was in the darkroom. The upper two records are of night and day activity of the mouse after it had been in the darkroom for over a month; the lower two records show the night and day activity of the same mouse after it had been exposed for a period to light at night, and was again in continuous darkness. It is thus clearly seen that the rhythm of activity of the forest deer mouse may be completely reversed by exposing the animal to a condition of light at night and darkness in the daytime, and this reversed rhythm persists when the mouse is afterward kept in continuous darkness.

In the experiments on the influence of light on the twenty-four-hour periodicity of activity, mice in the darkroom were likewise subjected to light from a powerful lamp—this time in alternate eight-hour periods, so the mice in effect experienced a sixteen-hour day instead of the usual twenty-four-hour day. Two cages were used, each containing a pair of mice. The first cage was about three feet obliquely below the lamp; the second was beside the first on the side away from the light. The mice in the first cage had just been brought into the darkroom; those in the second cage had been there more than a month. In the first cage (nearest the light) the periodicity was completely destroyed. There was no restoration of the rhythm when the mice were again placed in continuous darkness, even though in a neighboring cage there were mice which had a rhythm of activity. When these mice, in which the periodicity had been destroyed, were removed from the darkroom and placed in an attic room where they experienced a daily alternation of light and darkness, a daily periodicity of activity was restored. In the other cage (farther from the light) the periodicity of activity of the mice was not destroyed by alternate eight hours of light, though there was a tendency for the suppression of active periods at times when the light was being used. When the use of the light was finally discontinued and the mice were again in continuous darkness, there was evident again a well-marked twenty-four-hour periodicity of activity with the active periods somewhat shifted from their former time of occurrence. In neither case was the normal twenty-four-hour periodicity of the mice changed into or replaced by a sixteen-hour periodicity. Although,

as has been shown, the actual time of activity may be quite readily shifted, the general plan of a twenty-four-hour periodicity seems to be of a much more fundamental nature.

b. Temperature. In the activity experiments previously described the mice were kept at a nearly constant temperature of about twenty-one degrees Centigrade, except that the use of artificial light raised the temperature in the cages about four degrees. Under natural conditions, of course, the temperature is not constant; ordinarily there is a decrease in temperature, and an increase in the activity of the mice, at night. Therefore it has seemed worth while to test whether the time of activity would be affected by keeping the mice at a lower temperature. Accordingly, records were taken of mouse activity in a cold room, at an approximately constant temperature of ten degrees Centigrade. There was as little record of activity in the daytime at the low as at a higher temperature. Even when the nest was removed from the cage (so that the mouse would radiate heat more rapidly and hence, presumably, receive greater stimulus to activity) the daily periodicity of activity was not affected.

6. Physiological basis of rhythm

The activity rhythm of the mice is not produced by nor directly dependent upon a daily fluctuation of environmental conditions, and so is to be considered an expression of an internal physiological rhythm.

Richter (1922) noted a persistence of activity rhythm in albino rats kept in constant darkness. Gailbraith and Simpson found in monkeys a well-marked daily rhythm of body temperature[2] (higher during the day), and found that this thermal rhythm could be reversed by reversing the time of feeding and the time of light and darkness. Similarly in many warm-blooded animals there is known to be a daily rhythm of temperature; the rhythm of temperature corresponds closely to the rhythm of activity, and may be regarded either as a cause or an effect of the latter.

In view of the definiteness of the nocturnal activity of deer mice, and the deep-seated and fundamental nature of the rhythm, it seems certain

[2] In man there is a fairly definite thermal rhythm (Benedict and Snell) but apparently not a very persistent activity rhythm. Donald MacMillan, the arctic explorer, has said, in answer to inquiry, that the Eskimos have no regular rhythm of sleep and activity, and that white men in the north easily fall into the Eskimos' way of living, and show no trace of a twenty-four-hour periodicity of activity.

that the environmental conditions which are of most importance in controlling the activity of the mice must be those prevailing at night.

III. CLIMATIC CONDITIONS IN WOODS AND FIELD

Chenoweth (1917) and others have assumed that the mice are confined to their respective habitats by their reaction to climatic differences. It seemed desirable, therefore, to determine the actual climatic differences to be found in the habitats of the mice in the field and woods. Continuous records of temperature and humidity in woods and field were taken during the winter of 1924–25, and during a part of the preceding autumn and following spring.

The records were obtained by means of thermographs and hygrographs, placed in wooden shelters on the ground. One set of instruments was located in University Woods, near Urbana, Illinois. The other set was placed in an adjoining field, about seventy yards west of the edge of the woods. It was realized that the records would not show the conditions experienced by the mice in their underground nests, but they should show the conditions which the mice experience when they are active and come out from their nests; and it is the conditions at the time when the mice are active which may be expected to be most important in influencing their responses and distribution. That the climatic conditions recorded by the instruments were those actually experienced by the mice was more literally true than could have been anticipated; for forest deer mice lived under the log beside which was the shelter for the woods instruments, and a pair of prairie deer mice built their nest and raised a litter of young beneath the instrument shelter in the field.

In order to make it possible to compare conditions of temperature and humidity in woods and field at different times of day and in different months, monthly means were determined for each two-hour period. That is, monthly means were computed, separately for the temperatures and humidities of each station, for 2:00 p.m., 4:00 p.m., 6:00 p.m., etc., throughout the twenty-four hours. Climatic data in this form, for October[3] and February, are shown in figure 4. It may be noted that during October (and presumably to a still greater extent during the summer months) there is a much wider daily range both of temperature and humidity in the field than in the woods. During the winter months, as is shown for February, there is no significant difference

[3] Data for October are based on the last ten days only.

between the woods and field stations, either at night or any other time. In October the temperature is lower at night and the humidity higher

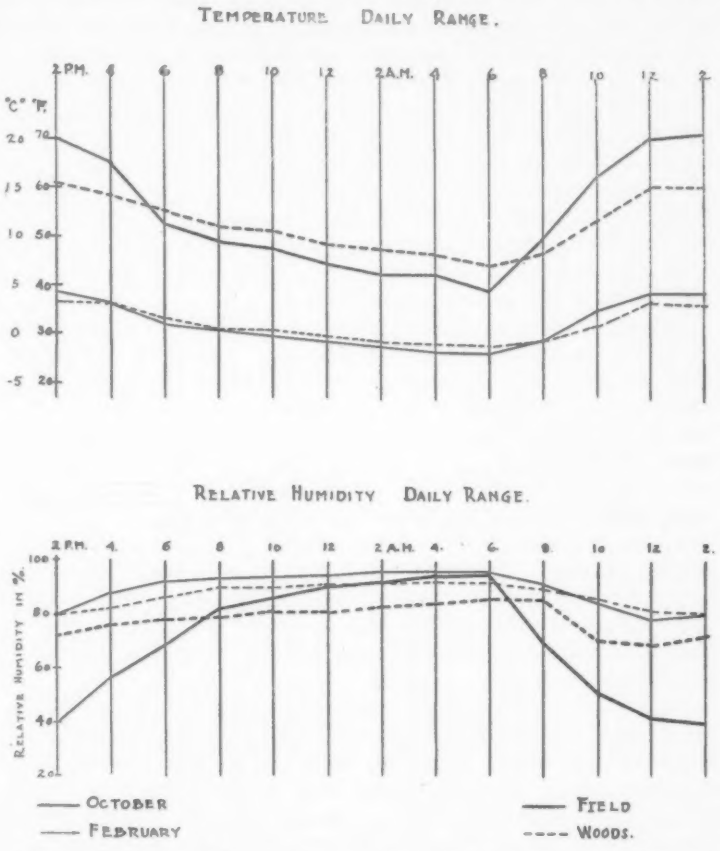

FIG. 4. COMPARISON OF TEMPERATURE AND HUMIDITY IN A FIELD AND IN WOODS, SHOWING THAT DIFFERENCES ARE SLIGHT OR REVERSED AT NIGHT

in the field than is the case in the woods, which is the reverse of conditions in the daytime. During these months, at least, there is no evidence that either species of deer mouse is restricted to its own

habitat as a result of differences in temperature or humidity between woods and field. From the work of other authors (Cuif, Mosier, Weese) on air and soil temperatures at different seasons, it seems probable that during the day (when the mice are quiet and in their nests) the prairie deer mice may in summer experience maximum temperature conditions at least eight degrees Centigrade higher than those experienced by the forest deer mice. On the other hand, the minimum air temperatures, such as the mice experience during the night when they are active and leave the nests, are little if any different in the woods and field. The situation as regards relative humidity is comparable to that of temperature. The difference between the mean relative humidities in the two locations in summer is due to the very low daytime humidity outside the woods. At night, when the mice are active, the field humidities are as high as those of the woods.

Rate of air movement, like temperature and relative humidity, fails to explain the local distribution of the mice. Two series of readings of air movement were made; one in October, and another in November after the leaves had fallen. The measurements were made with a Short and Mason anemometer. All readings show an increase of air movement with distance from the ground. Near the edge of the woods, and to an even greater extent outside the woods, this increase was rapid; in the interior of the woods before the leaves fell, the air movement was relatively small and the increase with distance from the ground was slow. Air movement in the woods is greatly increased after the leaves have fallen. Air movement on the ground in a cornfield or in thick grass in a field may be no greater than near the edge of a woods; and is less than air movement in the woods after the leaves have fallen.

The general conclusion to be drawn from a study of local climatic conditions in field and woods is that in winter there are no constant or appreciable differences. In summer the mice in the fields may evidently experience higher temperatures and lower relative humidities during the daytime; but at night, which is the time when the mice are active, any differences there may be between woods and field in temperature, humidity, evaporation, or air movement, are inconsiderable as compared with day-to-day variations in these factors. Chenoweth (1917) attempted to explain the fact that the habitat of the forest deer mouse is co-extensive with the woodland area by saying (p. 185) "The mice apparently avoid higher rates of evaporation by staying in the forest." Yet on the preceding page he had said "They may migrate to the forest

edge or to open cleared places a mile or so from the woods during the summer." It is in summer that evaporation and other climatic factors differ most between woods and field.

IV. REACTIONS AND HOMING PHENOMENA

1. Response to climatic conditions

a. Gradient experiments. In an attempt to determine to what extent, if at all, the distribution of the mice might be influenced by climatic factors, a study was made of the conditions selected by forest deer mice in a gradient of intensity of certain factors, and of the toleration by the mice of extreme conditions. Chenoweth (1917) and Dice (1922) have done work bearing on these points, and their results will be considered in connection with those obtained in the present study. Most of the gradient experiments deal with differences in air humidity and rate of flow. Air of different relative humidities or of different rates of flow was introduced into different sections of the experimental cage, and the portion of the cage (i.e., the air condition) selected by the mouse was observed and recorded continuously during the course of the experiment. The method of establishing the humidity gradient was essentially that described by Shelford and Deere (1913). For measuring the rate of air flow, to secure an equal flow in the different parts of the humidity gradient, use was made of apparatus designed by Shelford and Hamilton and described by Hamilton (1917). In principle this device is an inclined differential manometer measuring the difference in air pressure of the two halves of a chamber in the line of flow; the two halves of the chamber are separated by a diaphragm having an aperture of known diameter. In the experiments involving a gradient of rate of flow it was found desirable to use air flows greater than could be measured by the method in question. In all the experiments with air movement the rate of flow across the "wind" part of the cage was sufficient to spin a Short and Mason anemometer, the flow across the middle of the cage was barely sufficient to turn the anemometer, and no flow at all was used across the "quiet" part of the cage.

In many of the experiments the same rectangular gradient cage was used which had been used by Chenoweth. In other cases a circular cage was used, designed by Doctor Shelford and the writer to overcome the difficulty that, in a rectangular cage, the mice tended to remain in corners regardless of air conditions. As a control the gradient was reversed, usually at the end of thirty minutes, and the observation of

the mouse continued. The mouse was considered to have shown a selection of air conditions if it took up the same relative position in the reversed gradient as in the original. In only three of twelve humidity experiments and three of seventeen air movement experiments did the mouse appear to show definite selection of air conditions. That is, in moderate gradients of air humidity or air movement the mice do not consistently select conditions of moist or quiet air. These results are not in agreement with those of Chenoweth, perhaps partly because he used extremes of humidity much greater than the mice would ever encounter outside the laboratory. Three experiments with forest deer mice were made on response in a gradient of light, and one on response in a gradient of temperature of the substratum. The results were inconclusive and the experiments were discontinued.

b. Toleration. Chenoweth decided, on the basis of a few experiments, that high temperature, low humidity, or rapid air movement were fatal to the forest deer mouse. Dice did not confirm Chenoweth's conclusions, and thought it probable that Chenoweth's mice died because they were not given food and water. Dice found forest deer mice could live with a relative humidity of five per cent, and at temperatures above 36°C. (he did not use extremes of temperature and humidity at the same time), and were no less resistant to low humidities and high temperatures than the prairie deer mice. Dice also failed to find any difference between the two species in respect either to food or water requirement. Dice found that all three species he studied (forest and prairie deer mice and prairie vole) could live at a temperature of 0°C. with saturated air. In his experiments, however, the mice were provided with nests, which, while they (apparently) did not completely cover the mice, certainly offered some hindrance to radiation of body heat. In the present study a brief experiment was conducted in which two forest deer mice were kept outdoors more than five days at a mean temperature of less than 0°C. without any nest material at all. One mouse was kept in a metal tobacco can with a screen cover; the other was in a cage made entirely of ¼-inch mesh wire screen. Each mouse was provided with a small dish of food and one of water. During the experiment the food and water supplies were renewed as often as necessary, and the mouse in the metal can was removed while the can was cleaned. At the end of five days, when the experiment was discontinued, both mice were alive and in good health.

Data obtained by means of a thermocouple placed inside a forest deer mouse nest have shown that the nest temperature in cold weather may

be as much as 24°C. higher than that of the surroundings. When it is considered that at Urbana the average minimum temperature for the year of soil at a depth of three inches is −6.6°C. (Mosier, 1918), it is evident that even in the coldest weather the mice would not be subject to critically low nest temperatures.

Both the gradient experiments and the work on toleration indicate that these mice are not especially sensitive to climatic conditions.

2. Nesting site selection

It might perhaps be supposed that the forest and the prairie deer mice are distributed as they are, in a locality where both occur, as a result of their respective selection or avoidance of wood surroundings. It has been said (Wood, 1910) of the prairie deer mice that even in a cemetery in which they are very abundant in open places they are never taken in the neighborhood of shrubbery; and of the forest deer mice that their burrows are little more than passageways under stumps, logs, or similar cover.

The same authority states that he has never found a burrow of the latter species in the open without protection. On January 6, 1925, the present writer dug open a burrow of the forest deer mouse which, although in the woods, was not in the immediate shelter of any log or tree. Tracks in the snow led to the opening of an underground tunnel. The tunnel was considerably branched; one branch led toward a log about two feet distant, another led obliquely away from the log. The tunnel ran just beneath the two-inch crust of frozen ground. At a distance of two yards from the log was an enlargement of the tunnel (about two and one-half inches across) filled with a ball of chewed-up leaves. As this nest was examined a forest deer mouse ran out and across the snow to another opening where it disappeared. In contrast with this case where the nest of the forest deer mouse, although in the forest, was not in immediate contact with wood, may be mentioned the fact that a pair of prairie deer mice built their nest and reared a litter of young beneath a wooden instrument shelter in the field. With these field observations may be cited corresponding data on the behavior of the two species of mice in captivity. A pair of forest deer mice, provided with a wooden nest box, filled the box entirely with grain which they took from their food dish; they removed the nest material from the box and rebuilt their nest outside. A pair of prairie deer mice, on the contrary, provided with an empty wooden nest box, took their nest material into the box and rebuilt their nest there. All these

facts indicate that the local distribution of the two species of mice is not to be explained on the basis of selection or avoidance of proximity to wood.

3. Homing

There seems to have been no attempt to study the individual range of any small rodent. Seton (1909) in writing of the prairie deer mouse says he has no evidence of the home-range of the individual, but analogy would argue that it can not be more than 100 yards radius; and in the case of the Drummond vole he says the home-range of the individual is probably less than fifty feet across. During the summer of 1924 an effort was made to learn something of the individual range of forest deer mice by trapping individuals, marking and releasing them, and trapping them again. The mice were caught in small box traps, etherized, and marked by cutting their ears in such a way that they could be identified if recaptured. Altogether eighteen different mice were so marked, of which all but one were recaught at least once. Two were recaught seven times each. Mice once marked were released without etherizing whenever they were caught afterwards. Generally the same mouse was caught several times in the same place. The place where the mouse was caught was almost certainly the one nearest that mouse's home, and would seem to indicate that ordinarily the forest deer mouse stays rather near home. Most interesting results were obtained when the mouse was released at some distance from the place where it was captured. Mouse 14, which was caught near the edge of the woods at the southwest corner, was taken twenty yards into the cornfield which adjoins the woods on the south. The next day this mouse was in the trap in the same place where it had first been caught. This time the mouse was taken across the road to the west of the woods, and released in a hedge on the other side; it was found in the trap in its original location the next morning. Then this same mouse was taken 150 yards along the edge of the woods and released near some other traps; the following morning it was again found caught in its original location. Mouse 12 was taken about two hundred yards from the interior of the woods to the edge of the woods, and released; five days later it was found caught in a trap at the place where it had been caught first. Mouse 15 was taken from the edge of the woods about a hundred yards into the interior of the woods. It did not come back, but was caught several times afterwards in traps near where it had been released.

The tendency of the mice to remain in a definite location may be an important factor controlling or limiting distribution.

V. RELATION TO SEASONAL SOCIETIES

Weese (1924), in a year's study of the animal communities and seasonal succession in the University Woods found that "the most striking phenomena of the entire period covered by the collections were the hibernating reaction of the autumn, involving a migration inward from the forest margin and downward to the forest floor, and the migration in the opposite sense in the spring." Wood speaks of a migration of the forest deer mouse, saying they leave the thick woods in summer and are found along the forest border, and in the winter they are found in the deepest woods. In connection with the present study mice have been trapped at all seasons in the University Woods, and it has been found that both summer and winter they can be caught equally well in the interior of the woods and near the edge. After a snowfall in the winter time the tracks of the forest deer mouse can be found near the edge of the woods and in the interior of the woods. Although it seems certain that there can be no such general seasonal migration of the forest deer mice as Wood has supposed, it is true that in the fall forest deer mice may be caught in cornfields in the immediate neighborhood of the woods.

The invertebrates studied by Weese, especially those indigenous to the forest, were characterized by marked changes in numbers due to the appearance of large numbers of young—either before or after the adults had disappeared. Such changes, however, do not apply in the case of deer mice which are not limited to any definite season of reproduction. Wood (1910) reported that young of the forest deer mice are born at all times of year from January to October inclusive. An examination of four adult females caught in November showed one, caught November 26, which was nursing. Scheffer (1924) reports, for another species of *Peromyscus* (*P. maniculatus gambelii*), that it breeds at all seasons of the year. Deer mice do not hibernate, and their tracks may be seen after any snowfall. Both the forest and the prairie species lay up stores of seeds for the winter.

From what has been said it is evident that the deer mice are related to the biotic association as a whole, rather than to any particular seasonal society. In view of its large numbers—each species of deer mouse is undoubtedly the most abundant mammal in the biotic association in which it occurs (Hahn, 1909; Wood, 1910; and trapping records in the present study)—and its presence and activity at all seasons, the forest deer mouse certainly is to be considered one of the

dominant animals of the deciduous forest. The relation of other mice to seasonal societies has not been worked out. House mice are known (Wood, 1910) to migrate in large numbers into grain fields in the fall.

VI. MOUSE NUMBERS AND RANGE

As growth is taken to be an indication of conditions favorable to the individual, so may increase in numbers be regarded as an indication of conditions favorable to the species. In most mammals great increases in numbers are not now known, but quantitative studies in the future will probably show that such variations in numbers are of rather general occurrence. In a few animals, where the fluctuation in numbers is particularly pronounced or becomes of economic importance, we have a fairly definite knowledge of the times of greatest abundance. Among the mammals whose numerical fluctuations are thus a matter of record may be mentioned the Norway lemmings, rabbits and foxes, and meadow mice or voles. Since the fluctuations in numbers of meadow mice are more pronounced and the times of great abundance better known than in the case of other mice, the meadow mouse is especially suited to a study of the conditions favoring its success and increase.

The facts concerning excessive increase, or "plagues" of mice may be summed up as follows:

Great increases in numbers of mice occur from time to time.

These increases may involve a number of kinds of mice. (Elton, 1924; Howell, 1923.)

Mouse plagues must be due to general rather than purely local causes, for they occur over wide areas or sometimes in different countries simultaneously. (Elton, 1924.)

Mouse plagues may be accentuated by destruction of the natural enemies of the mice, but they are not caused by this destruction, for plagues occur—as in Thessaly (Harting and others, 1893) or La Plata (Hudson, 1892)—when there has been no destruction of natural enemies, and destruction of natural enemies does not always produce the plagues (Harting and others, 1893).

Conditions known to be favorable to increases of mice are mild winters or a covering of snow, dry springs, and wet summers and falls (or irrigation) to provide abundant vegetation for food and shelter. (Elton; Harting and others; Lantz, 1907; Piper, 1909.)

In all the cases recorded of destructive plagues of mice, the damage has been due to abnormal increase of mice normally present in the region. In Thessaly and Scotland (Harting and others, 1893) the mice were confined almost entirely to uncultivated land; in other cases mice have done extensive damage in cultivated fields, to crops of all

sorts. Always, as the food supply in one area is exhausted, the mice move on and on to fresh territory. But neither the increase in numbers nor in territory is permanent. After a brief period of maximum abundance the mice practically disappear as a result of disease (and usually also unfavorable climatic conditions and increase of natural enemies). *Neither scarcity of foods nor pressure of numbers will suffice to establish the mice permanently outside the types of biotic community in which they are at home.*

On the other hand, permanent increase in numbers of mice, both within a given locality and over an extensive area, may accompany an extension of the type of biotic community suited to them. Wood (1910) says of the prairie deer mouse: "Owing to the clearing of woodland and the drainage of waste tracts, the area of its habitat within the county has undoubtedly greatly increased since the settlement of the country, and, considering its advantageous adaptation to the present state of cultivation, it seems quite certain that there are more individuals within our limits now than when the country was unsettled, and that its numbers are not decreasing at present." Similarly, Piper (1909) writing of the Nevada plague of field mice, said: "Agricultural development, however, distinctly increases the danger . . . . by increasing the area in which they find favorable homes. The reclamation of arid lands affords most suitable conditions in large areas which were formerly uninhabitable." In the case of the forest deer mouse, on the other hand, agricultural developments involving clearing of the woodland must be a factor limiting distribution. Not only through the artificial changes imposed by agriculture, but also by the slow changes of biotic communities involved in ecological succession, may the numbers and range of the mice be controlled.

VII. GEOGRAPHICAL DISTRIBUTION

Four kinds of mice are found wild in the vicinity of Urbana. These are the forest deer mouse and the prairie deer mouse, which have been mentioned already, and the prairie vole (*Microtus ochrogaster* (Wagner)), and the house mouse (*Mus musculus* L.).

The house mouse is an introduced species of almost world-wide distribution. It has established itself in the temperate zones wherever civilized man has gone. The range of the northern variety of forest deer mouse (which is the form found in Illinois) extends "from Nova Scotia to central Minnesota, thence south through the humid parts of eastern

Kansas and Nebraska and eastward to the Atlantic coast" (Osgood, 1909). The prairie deer mouse occurs, according to the same author, in the "prairie region of the upper Mississippi Valley in southern Wisconsin, Minnesota, Illinois, Indiana, eastern Ohio, Iowa, Missouri, Oklahoma, and the eastern or humid parts of Kansas, Nebraska, South Dakota, and North Dakota; north to southern Manitoba." The prairie vole has a more restricted range than any of the other mice considered. According to Bailey (1900) it occurs in the "central part of the Mississippi Valley from southern Wisconsin to southern Missouri and Fort Reno, Oklahoma, and west into eastern Nebraska and Kansas."

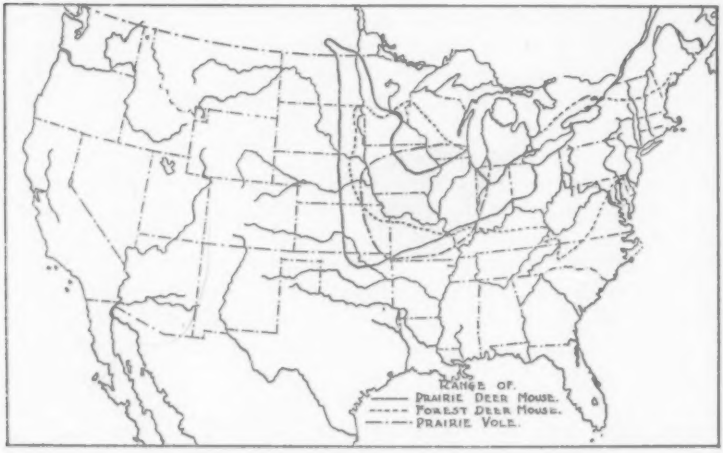

FIG. 5. GEOGRAPHIC RANGES OF MICE STUDIED

Dice (1922) included part of southern Michigan in his account of the range of the species. In the map of the geographic range of these mice (fig. 5) the house mouse is omitted, because of its universal distribution. The ranges of the two species of deer mice are copied from maps by Osgood (1909). The range of the prairie vole is taken from published descriptions, for no maps are available. An examination of figure 5 serves to emphasize, more than a verbal description could, the extent to which the ranges of the different species overlap.

Even though occurring in the same general localities throughout considerable areas, the different species are nearly always confined to

different local habitats (different biotic communities). As has already been stated, the forest deer mouse is confined in its local distribution to deciduous forest, where it is probably the most abundant mammal (Hahn, 1909). Sometimes surprisingly little woods is required for the mouse—perhaps a clump of bushes, or a stump or fallen log; this is especially true if the land was originally wooded and is near an area that is still wooded. However, forest deer mice have been caught in the University Forestry, which is entirely artificial and is miles from any natural woods. While it is true that *P. l. noveboracensis* is a forest animal, yet individuals may be caught outside the forest. In the autumn when the corn is ripe, several specimens have been caught in a corn field at a distance of one or two rods from the edge of the woods; one forest deer mouse was taken in a corn field at a distance of a quarter of a mile from the nearest woodland. Wood (1910) said that the forest deer mice enter grain and corn fields if these are near woods.

The prairie deer mouse is characteristically an inhabitant of the open fields. The present writer has never caught a specimen in the woods, or even in the neighborhood of shrubs or hedges. These mice are always common in fields of grain or alfalfa. Cultivation of the soil does not seem to disturb them in the least. It has been found that specimens might be secured readily by trapping in the winter in perfectly bare ploughed fields where corn had been raised the previous season. Wood (1910) reported capturing numbers of them in the middle of large fields of young growing corn, which were thoroughly cultivated every few days. On the contrary, the prairie deer mouse is not likely to be found in neglected areas such as the matted grass of roadsides.

The prairie vole is to be found in uncultivated areas in the open where long tangled grass furnishes cover for its network of runways. It is never found in the woods. Favorite habitats are roadsides, and along fences between fields.

The house mouse is far from being as restricted in its local distribution as its name would imply. The writer has captured this species in the tangled grass of the Vivarium grounds, in neglected roadside areas, in pastures, in fields of alfalfa and other grassy crops, in fields of various kinds of grain; and one specimen (and only one) has been taken in the University Woods, about a rod from the edge of the woods.

The same species may occur in several associations, as was indicated in the brief summary just given of the local conditions under which the different kinds of mice have been caught. Each species, however,

seems to be limited to a certain type of association, and of the three species considered (excluding the house mouse) there is practically no mingling of habitat. All the different conditions mentioned here, which serve to restrict the local distribution of the different mice, and a great variety of other local conditions might be included together in a single formation.

Some consideration should be given to the relation of mice to biotic association types before there was extensive disturbance resulting from cultivation. Various kinds of deciduous forest are climax associations throughout the range of the forest deer mouse; and as the latter is characteristically a woodland species, its distribution is probably affected by agricultural developments only as it is limited by destruction of the forests. Throughout the range of the prairie vole the subclimax prairie alternates with deciduous forest. According to Clements (1920, p. 132):

> The western limit of the subclimax prairie . . . . runs through Minnesota, Iowa, Nebraska, and Kansas, and northern Oklahoma. It is impossible to draw the limits in the east, north, or south, not merely because of lack of knowledge, but also because its occurrence is more and more local in character and successional in nature the farther east one goes.

Consociations

Andropogon furcatus	*Bouteloua racemosa*
Andropogon nutans	*Elymus canadensis*
Andropogon scoparius	*Panicum virgatum*
Andropogon saccharoides	*Spartina cynosuroides*

The *Andropogons* are by all odds the most important dominants of this association. They give it the distinctive impress everywhere in the transition areas.

Neglected areas of roadside or railroad right-of-way, and the uncultivated strips along fences between fields, are the nearest approach there is at present to the prairie associations which formerly prevailed throughout the range of the prairie vole. Sampson (1921) has shown that the dominant grass in such an uncultivated area is, or becomes when it is left undisturbed, the tall bluestem (*Andropogon furcatus*); and both he and Clements (1920) state that this *Andropogon* was the most important dominant of the original prairie association. As the prairie vole is found in precisely such undisturbed areas, there is every probability that it was fully at home in the original prairie type of biotic associations.

Mention has already been made of the fact that the prairie deer mouse is characteristically an inhabitant of cultivated fields, and that it is

not found in the relativly undisturbed areas which are the habitat of the prairie vole and which most nearly resemble conditions in the original prairies. Dice (1923, 1923a) found that in Riley County, Kansas, prairie deer mice were most abundant on rocky ground, where grasses and sedges were nearly absent. He also found numbers of them in "prairie," and in a community of sumac scrub where there was a growth of grass beneath the sumac, but the plants he lists from these habitats were not characteristic of prairie vegetation as described by Clements (1920) or by Sampson (1921). As the trapping of mice by the present writer was primarily to obtain specimens for experimental work rather than to determine their original habitat, and as it was evident early in the work that they were most abundant in cultivated fields, no data as to original habitat have been obtained. Since prairie deer mice were not caught in the thick grass of uncultivated areas where the prairie vole was found, they must evidently have belonged to some subclimax communities, rather than to the *Andropogon* climax type of prairie association. The records given by Dice accord with this view. Trapping is being carried on in various more or less natural stages of prairie succession to determine the type of ecological community of which the prairie deer mouse was a member before cultivated fields were available to it as a habitat. As was suggested in the preceding section, the prairie deer mouse has probably increased greatly both in local distribution and extent of range as a result of use of the land for cultivation. By cultivation the land is kept in an early stage of prairie succession; and it is probable that experience will show that prairie deer mice are confined to early stages of prairie succession in land not under cultivation.

In addition to the cases of the forest and the prairie deer mice and the prairie vole, where the restriction of different species to different types of habitat has been observed first-hand by the writer, other instances may be mentioned of similar restriction of different mice in the same locality to different types of habitat. *Peromyscus maniculatus gracilis* (LeConte) is distributed, according to Osgood (1909) in "northeastern United States and southern Canada from northern Minnesota east through northern Wisconsin, Michigan, Ontario, Quebec, New York and western New Engand." In general the southern limit of distribution of this species corresponds fairly closely to the northern limit of *P. l. noveboracensis*, as may be seen from figure 5. There is, however, a considerable amount of overlapping of the distribution areas of the two species, particularly in the eastern part of their range. That they

are none the less restricted to different biotic associations is pointed out by Osgood: "Although living in the same general localities, *gracilis* and *noveboracensis* are nearly always confined to different local habitats, *gracilis* showing preference for the colder, more moist places or deep, mostly coniferous woods; *noveboracensis* for the warmer, dryer, more open country, or deciduous woods."

Since it has already been shown that differences in climatic conditions between the different habitats are not sufficient to explain the local distribution of the mice, and the mice are not limited by food or water requirements or antagonism between the species (Dice, 1922), and nesting material or nesting sites are not limiting factors, it seems evident that the restriction of the mice to certain types of biotic associations is due to the relation of the mice to the association as a whole, rather than to any single factor of the environment.

It is not to be inferred that all mice are as sharply limited to certain types of biotic associations as are those in the examples given; it is evident, however, that in the case of mice which are so limited the range of the mice does not go beyond the extent of the biotic associations to which the mice belong.

VIII. CLIMATE AND RANGE

1. General and local conditions

In connection with a study of the distribution of any organism, it is important to consider the possible influence of climatic conditions. The only available data of climatic conditions over any considerable area are the meterological records published by the Weather Bureau. If one is to use such data, he should first determine whether the official records correspond to the conditions which actually prevail in the habitat of the animal studied. Temperature records taken by Weese (1924) from July, 1921, to June, 1922, in the University Woods did not at any season show any consistent departure in weekly means, mean minima, or mean maxima, from the official records for Urbana during the same period. That is, in this instance official records are indicative of conditions in the habitat of the mouse.

To facilitate comparison of climatic conditions in the range of different mice, graphs were made of temperature-rainfall (hythergraphs) and of temperature-humidity (climographs). The methods used were patterned to some extent after those used and described by E. L. Johnson (1924). Monthly means of temperature and rainfall, and of

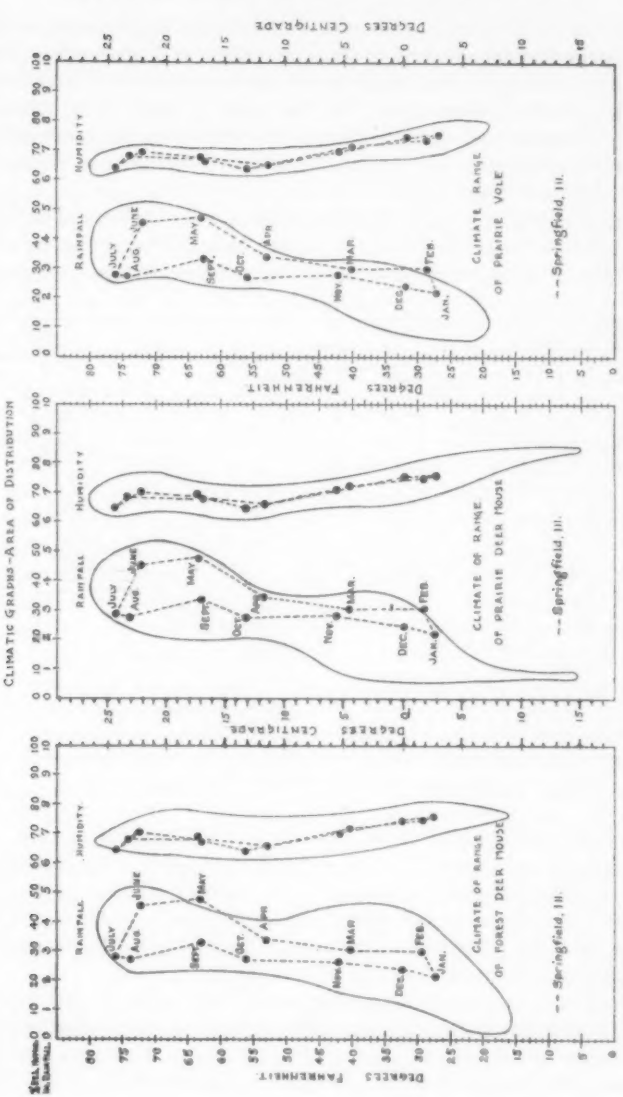

FIG. 6. CLIMATIC LIMITS OF SPECIES AND VARIETIES OF MICE STUDIED, BASED ON NORMAL MONTHLY TEMPERATURE, HUMIDITY, AND RAINFALL

temperature and humidity, were plotted for all the months and for all the Weather Bureau stations within the range of the mouse. The figures produced by drawing lines enclosing the points so plotted indicate, by their position and form, the climate of the range of the mouse. Both hythergraph and climograph may be plotted on the same sheet of cross-section paper. The climatic data were obtained from Weather Bureau Bulletins Q and W.

In figure 6 are given climatic graphs of the ranges of forest and prairie deer mice and the prairie vole. To make comparison of the graphs easy, there is given in each a representation of the climate of Spring-

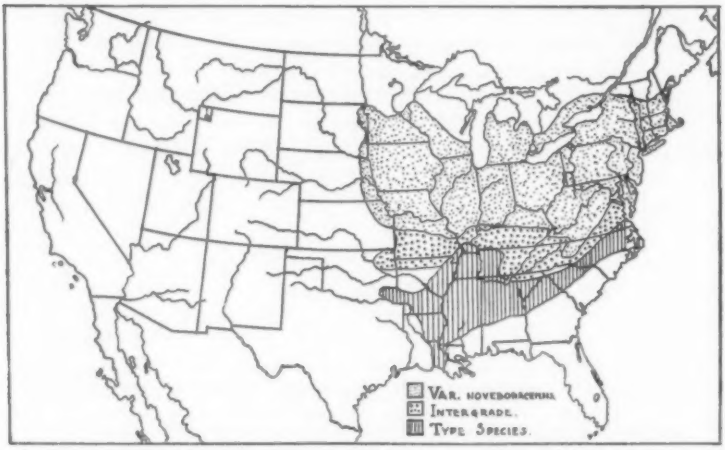

FIG. 7. DISTRIBUTION OF VARIETIES OF DEER MICE

field, Illinois, which is common to all. In view of the great amount of overlapping of the ranges of these mice, it is not surprising that the graphs should show great similarity. Such climatic differences as are here shown are probably not directly of significance in delimiting the range of the mice. The differences seem to be related to the extent of the biotic associations in which the mice make their homes.

The forest deer mouse has been found to be restricted to the deciduous forest. It does not follow that the range of the forest deer mouse found in this region should extend throughout the area of deciduous forest. The forest deer mouse found in Illinois, *P. l. noveboracensis*, is but the

northern variety of the typical species, *Peromyscus leucopus*. The area of distribution of the two forms, as given by Osgood (1909), is shown in figure 7. Between the territory occupied by the typical species and that of its northern variety is a wide area in which are found intermediate stages between the two. Altogether, these mice occupy the whole of the eastern deciduous forest area, being limited on the north by the northern evergreen, on the west by grassland, and on the south by the southeastern evergreen forest (Livingston and Shreve, 1921).

Within the limits of a single biotic association, then, in different parts similar ecological niches are occupied by different forms. As in a given locality and climate the distribution of the different mice has been shown to be dependent on the biotic associations type, so in a given extensive biotic community, the distribution of geographic varieties of mice can be shown to be dependent on climate.

Climatic graphs, constructed according to the method already described, have been prepared for the area of distribution of the typical species, the intergrading forms, and the northern variety of the forest deer mouse (figure 8). A comparison of the graphs shows an agreement between climatic conditions, particularly winter temperatures, and the distribution of varieties of forest deer mice.

Humidity differences, as well as temperature differences, may be correlated with the distribution of geographic races of mice within a single biotic association. Sumner (1920) writing of the differences of local collections from different parts of the range of the same subspecies of *Peromyscus maniculatus* (*P. m. gambelii*), after emphasizing that the local races with which he dealt were "simply samples taken at various arbitrarily chosen points from a perfectly continuous population," said: "If we consider only the coastal stations from San Francisco Bay northward (Berkeley, Duncan Mills, Fort Bragg, Eureka), which probably present a graded series in respect to both temperature and atmospheric humidity, we find likewise a similar gradation in respect to" various bodily dimensions of the mice. That the effect of climate is on the distribution of the mice, and not on the production of the bodily differences, is indicated by the fact (Sumner, 1924) that geographic races of mice do not tend to become more alike as a result of being transplanted to the same locality. It seems clear, from the two examples given, that climate may act to limit the distribution of the mice within the biotic community to which they are related, as well as limiting their distribution by limiting the community as a whole.

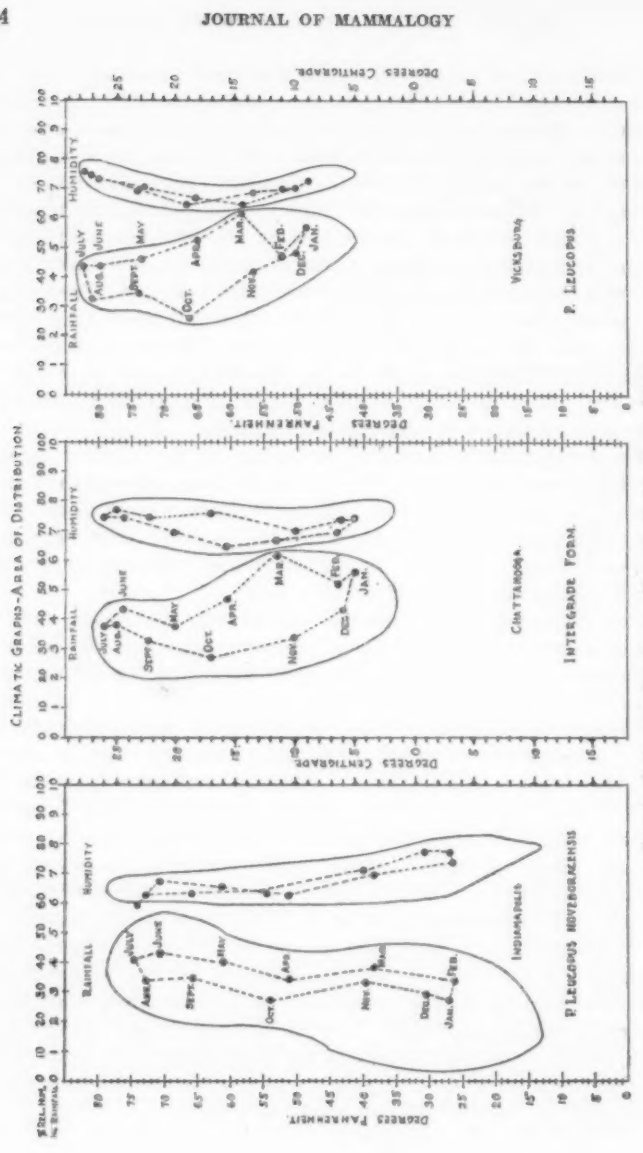

FIG. 8. CLIMATIC LIMITS OF VARIETIES OF DEER MICE

IX. SUMMARY

1. Forest deer mice are nocturnal; there is a well-marked rhythm of activity which persists in the absence of any daily change of light, but the rhythm may be reversed or otherwise modified by the use of light.

2. Both field and laboratory studies indicate that climatic factors are not sufficient to explain the restriction of forest and prairie deer mice to woods and field respectively.

3. Nesting sites do not explain the restriction of habitats of forest and prairie deer mice.

4. Forest deer mice caught in a given place and released may be caught again in the same place, even though they had been carried outside the woods or as far as two hundred yards through the woods away from their original location before being released.

5. Permanent increase of numbers or range of mice is dependent on increase of the type of biotic association in which the mice are at home.

6. The whole biotic association type, rather than any single factor of the environment, is of primary importance in the distribution of these mice.

7. Within a single type of extensive biotic community, the distribution of varieties of mice (equivalent dominants) corresponds to climatic differences.

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University Farm, Saint Paul, Minnesota.

CAMERA-TRAPPING—A NOVEL DEVICE FOR WILD ANIMAL PHOTOGRAPHY

By Henry R. Carey

[*Plates 20–26*]

The ancient and honorable sport of camera-trapping has had many adventurous and inventive devotees. The Hon. George Shiras, 3rd, appears to have originated the idea of setting up a camera and flashlight apparatus in the woods, so that a bird or mammal, on tugging at a bait or in travelling on its runway, will, by pulling a wire, take its own photograph, while the owner of the camera may be miles away. Dr. Frank M. Chapman is, so far as I know, the pioneer in making birds photograph themselves on alighting upon a specially prepared perch. I well remember attending a lecture of his in Boston, about 1902, in which he showed photographs of bluebirds, taken by themselves, when they alighted for a moment on an electrically wired branch. My youthful enthusiasm having been aroused by his example, I went to work on a similar device (shown in figure 4) which I had made thoroughly reliable by 1911. Other successful users of camera-traps of their own contriving are C. G. Schillings of Germany, whose pictures of African game are classics; Oliver G. Pike of England; John T. Coolidge, Jr., of Boston, Massachusetts, probably the first man to take flashlight portraits of lions from an African blind; William Nesbit, who has done more than anyone in making this sport practicable for beginners; and Joseph B. Taylor of New York.

Figures 1 and 2 show my apparatus set for action, the wooden box being fitted to take inside it a 4 x 5 Tourist Graflex camera. The box is fastened, by a tripod screw-plate in the bottom, to a strong tripod, and is pointed toward the spot where the bird or other animal is expected. The wooden plug (A) is fastened by a piece of No. 26 soft brass wire to the bait, or the wire is run across the trail used by the animal, or a piece of linen pack-thread is extended to the bird perch (fig. 4) and fastened to the falling weight (B) which is liberated when the bird alights on the perch at F. In any case, when the bird or fur-bearer pulls at the bait or runs into the wire across his path, or sits on the perch, the plug (A, fig. 2) is pulled out, the lever (B) falls, and the spring (D) causes the pistol hammer (C) to strike a sharp blow on a 32 calibre blank cartridge. This fires a spark into the tin receptacle (E), through a hole one-quarter inch in diameter, and ignites a large charge of very

slow flash powder, contained in a water-tight cardboard pill box, which has been dipped in hot paraffin. The powder shoots out, burning, through the opening shown in E, but is prevented from throwing light and smoke into the lens by the flash-shield (K). Indicated by L (figs. 2 and 3) is a tin reflector behind the flash, to increase its brilliancy. At the moment when the hammer (C) is one millimeter from the cartridge, the hammer releases the L-shaped lever (F), which moves on the pivot (G), travelling as shown at I (fig. 2). This movement releases the focal-plane shutter catch at J, the catch being moved by a small spring. The shutter may be set at low speeds, but is preferably used, for flying birds and quick moving animals, at $\frac{1}{250}$ to $\frac{1}{1000}$ second.

It will be seen that by this means the shutter and flashlight are made to work absolutely simultaneously. The flashlight insures proper lighting at all times, day or night, and the speed of the shutter guarantees a sharp picture of even a flying bird.

If it is desired to photograph a bird on its favorite perch, the perch is sawed off flat on top, and the apparatus shown in figure 4 is fastened to the perch. When the bird alights on F, its weight causes the motion, shown by the dotted lines, on the pivot of stout iron wire (G). This motion causes D, a short bit of the strong iron wire pivoted on a screw-eye, to fall, releasing the metal hook (E), which falls with B, a heavy lead sinker. The fall of this weight tightens the strong thread (A, fig 4), and pulls out the plug (A, fig. 1) of the camera-trap at the other end of the thread. A retarding device (C) prevents the weight from falling until about three seconds after the bird hits the perch. It is useful for large birds, so that they will have time to fold their wings before the photograph is taken. The hook (E) may be inserted directly into the weight, and the weight should touch the upright perch. This will prevent the weight's swinging in the wind, which would set off the perch at the wrong time.

The writer will be glad to communicate with anyone interested in making a camera-trap for himself, and will give more complete details as to how the apparatus is made and set. It is not patented.

As flash-powder is explosive and dangerous, it should be handled with extreme care. In drawing back the pistol hammer (C, fig. 1) a wooden safety-plug (not shown in diagram), pivoted on the wooden upright to which the pistol is attached, should *immediately* be placed between the pistol hammer and the blank cartridge to avoid an accidental explosion of the flash-powder before the camera-trap is completely set. *The safety plug should not be swung out of the path of the hammer until the setting is otherwise complete.* This precaution will avoid accidents.

Some of the devices of other persons set off the flashlight by electrical, others by mechanical means. The writer believes the special advantages of his apparatus, which was first successfully used in 1910, to be as follows:

(1) The shutter used is the focal-plane variety, working simultaneously with the flashlight. Hence faster exposures may be made than with any device using a between-the-lens shutter. Clear photographs may be made of birds on the wing even within four feet of the lens, the shutter being set at $\frac{1}{1000}$ second. The use of flash-light at all times, day or night, ensures a correct exposure. Standard Eastman cameras may be used, which carry the regular focal plane shutter, with or without mirrors ("graflex" or "graphic").

(2) The apparatus is entirely rain-proof and may be left, set, out of doors for weeks at a time. Dampness will not spoil the Eastman "Speedway" or "Standard Orthonon" plates used, and a completely moisture-proof camera is not necessary.

(3) As the flashlight is fired by a specialized pistol, which explodes a blank cartridge into the powder charge, the machine can be used in zero weather. There are no batteries to be spoiled by freezing, as is the case with other contrivances.

(4) The outfit may be set in fifteen minutes. Other apparatus is more intricate, and an hour is consumed in setting.

(5) The device is very compact, and is not prevented from working by a fall of snow, provided a roof of branches two feet square be built above it. Other machines, in which the flashlight is several feet from the camera, require long wire connections, which are thrown out of working order by snow. A regular shanty would have to be built to protect them.

(6) The synchronization of shutter and flashlight does not vary. A very slow flash-powder is used so that its exploding can not jar the camera. Furthermore, since plenty of powder is used and since the duration of the flash is considerably slower than the time taken for the focal-plane shutter to operate, a possible slight decrease or increase in the speed of this powder can not result in under-exposing any part of the negative. Such slight variations have no effect on the exposure.

The camera-trap is a sort of detective of the woods. It has the patience of Job, and it is not subject to mosquito bites. It is noiseless, as well as patient, and it gives off no "body scent," as a human being does, to frighten the timid deer, bear or beaver. Its big round glass eye never slumbers. One evening in September, 1908, I set my camera-trap near a woodchuck's hole on the edge of a pine wood, so that a

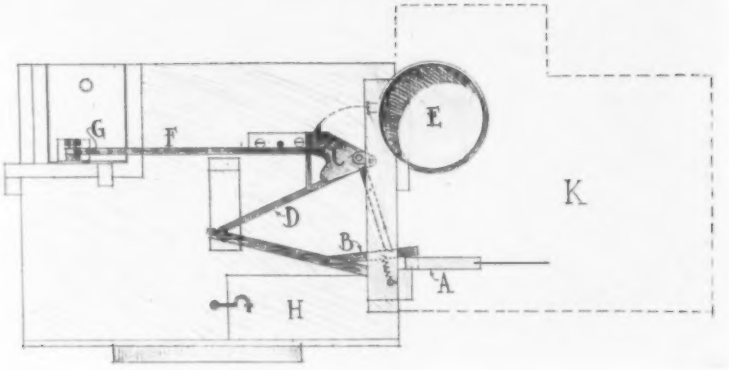

FIG. 1. THE CAMERA-TRAP SET. SIDE VIEW
Diagram by J. Fletcher Street

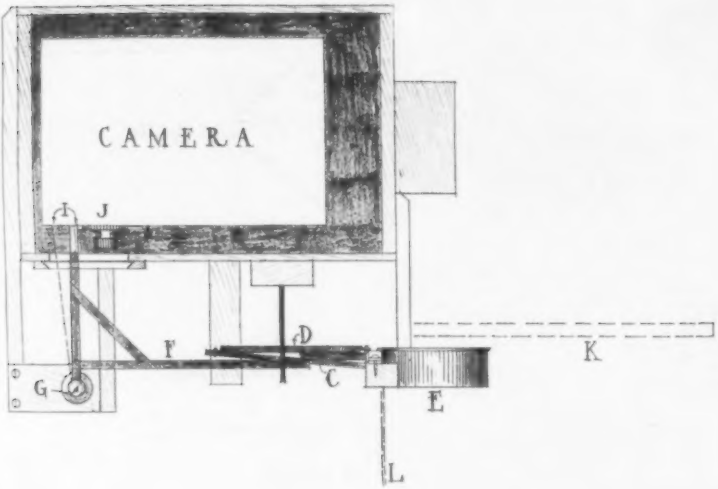

FIG. 2. THE CAMERA-TRAP SET. VIEW FROM ABOVE
Diagram by J. Fletcher Street

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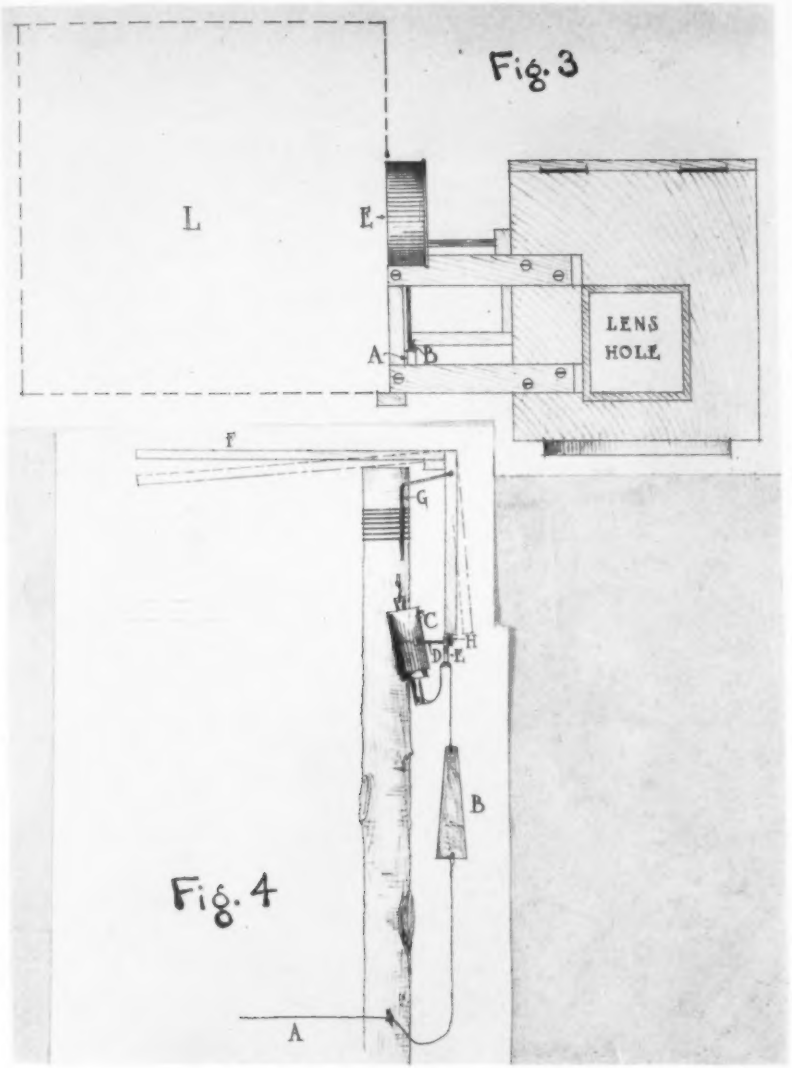

FIG. 3. THE CAMERA-TRAP SET. FRONT VIEW
Shows flashlight container (E) and reflector (L). Diagram by J. Fletcher Street.

FIG. 4. THE AUTOMATIC PERCH
When a bird alights at F, the lead weight (B) is released and pulls the thread (A), which sets off the flashlight and shutter. Diagram by J. Fletcher Street.

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FIG. 5. FLORIDA OPPOSSUM, SEIZING WOODPECKER BAIT

Photographed near Lake Harney, Orange County, Florida, at 8:53 p.m., August 2, 1910. Note the white face. Is it a freak? Exposure speed $\frac{1}{500}$ second. The first super-speed camera-trap photograph of an animal ever made.

FIG. 6. BEAVER ON TOP OF DAM

Photographed in Monroe County, Pennsylvania, August, 1924. The beavers are "coming back" in parts of Pennsylvania, having been virtually extinct throughout the state for many years.

FIG. 7. VARYING HARE IN WINTER

Camera-trap photograph taken on a runway in the snow in Canadian life-zone at 1,800 feet, Fern Ridge, Monroe County, Pennsylvania, at 5 p.m., December 30, 1922. Exposure $\frac{1}{50}$ second. The camera-trap wires may be dimly seen.

FIG. 8. NINE-POINT BUCK WHITE-TAILED DEER WITH HORNS IN VELVET

Photographed in Monroe County, Pennsylvania, August 17–26, 1923. The buck is not sampling a "salt lick," but is sniffing for reasons unknown at a small rock imbedded in the old logging-road along which he was moving.

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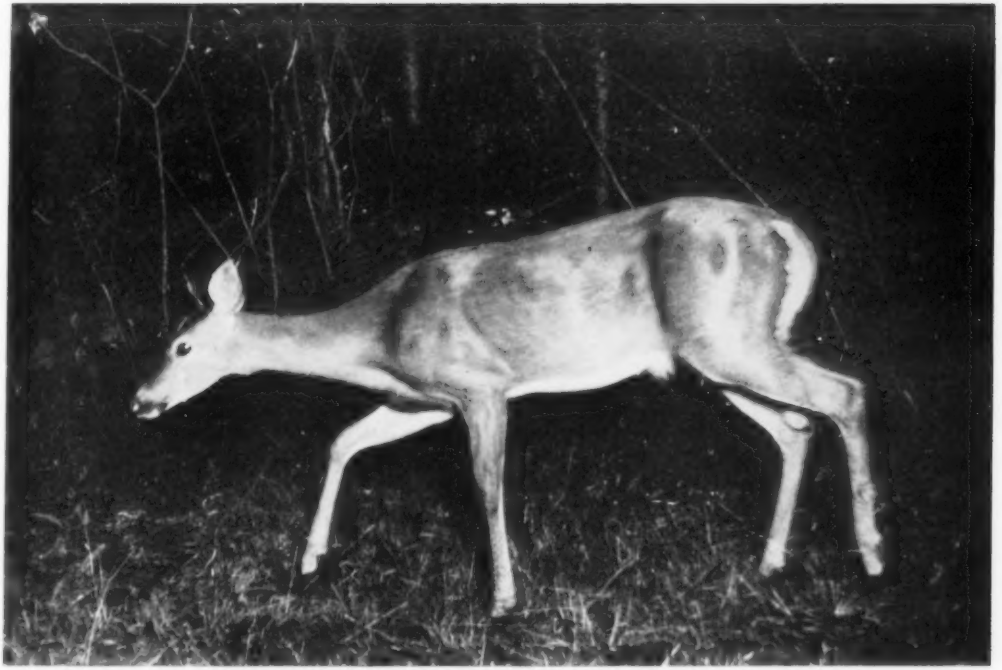

FIG. 9. SPIKE-HORN BUCK WHITE-TAILED DEER

Photographed in Monroe County, Pennsylvania, July 29–August 9, 1923. Distance 15 feet, aperature F8, exposure $\frac{1}{250}$ second. The flashlight was taken by the animal while it was passing along an old wood-road.

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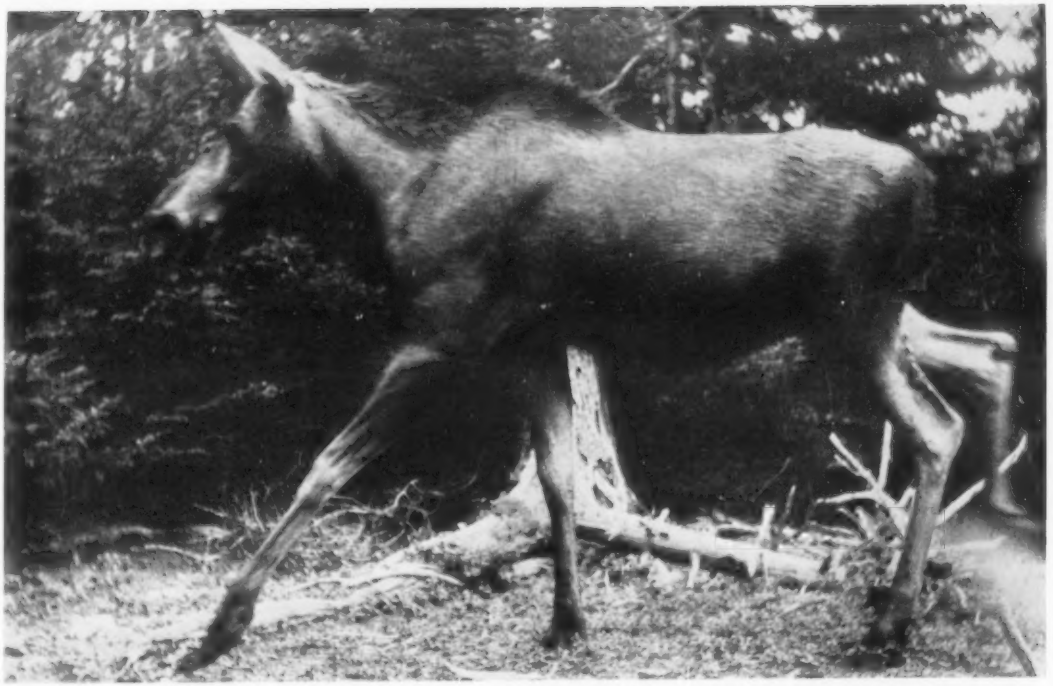

FIG. 10. COW MOOSE IN WOODS

She is trotting along an old logging-road, leading up from the banks of a small stream near Sebois Lake, Maine, August 11, 1908.

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woodchuck going in or out of the hole would bump into a wire and take his flashlight photograph. Next morning at eight o'clock I found that the trap had been sprung, and, if I remember rightly, the stop-watch in the box had been stopped at 4:30 a.m. Imagine my surprise when, on developing the plate, I found a beautiful photograph of a woodchuck, which showed plainly that the animal had entered this hole *during the darkness of night.* This seemed like proof that my woodchuck was a night prowler, but I had always read in the books that it travels about only after sunrise and before sunset. A year later, in September, 1909, I got another flash of a woodchuck, this time leaving its hole. From a quarter of a mile away, I saw the flash, and heard the detonation. I looked at my watch. It was 10:15 *at night.* Here was proof positive that my woodchuck was nocturnal. No wonder the farmer does not always succeed in shooting them. Perhaps my woodchucks were in a hurry to store up enough fat to enable them to sleep comfortably during the winter, and so foraged for food at night as well as by day when the crisp nights of autumn gave warning of the coming cold. Both my night pictures were taken at the beginning of the cooler weather (September, Portsmouth, New Hampshire).

Another time, in Florida in 1910, I got a beautiful flashlight of an opossum with a milk-white face, though the mammalogists say that no such form has been collected in that part of Florida. Was it a freak, or possibly a new species?

The camera-trap gives us interesting information about the food habits of birds. Thus Joseph B. Taylor states that his camera-trap has proved that great blue herons will take a bait of dead fish, thus refuting the testimony of persons who would withdraw the protection of the law from these beautiful birds, on the ground that they catch only *living* fish, such as trout, and thus interfere with the angling of the "sportsmen."

My photographs of night herons show that immature birds will take dead fish, but I have never attracted an *adult* to such a bait. They are expert fishermen, and prefer the live, fresh, and wriggling variety. Not so the young birds, which are clumsy lungers, and must often go home to roost half-empty.

Camera-trapping is a fascinating sport, and the photographs of living things, completely at ease, in their natural surroundings and unharmed, are far more interesting than their dead skins, the only product of trapping, old-style.

Philadelphia, Pennsylvania.

SOME HABITS OF MOUNTAIN LIONS IN ARIZONA

By M. E. Musgrave

Although from childhood I have been more or less familiar with the mountain lion, or cougar, as it is known in the northwest, I did not become intimately acquainted with this animal until I took up predatory-animal work in the southwest, which afforded me an excellent opportunity for a close study of its habits on the range. Since 1918 our force of men has killed more than 600 mountain lions in Arizona, and from all the data we have gathered concerning this large number, I believe that some questions which have long puzzled us may at last be solved.

Let us consider, for instance, the time of breeding. It has been the firm belief of some that the young of this tribe are born only in the spring, but evidence now proves conclusively that this is not necessarily the case, for we have found kittens during every month of the calendar, and at altitudes ranging from three thousand to seven thousand feet. A favorable temperature, therefore, is not a factor in the birth of the lion's young.

These cubs, ranging in number from one to four, are usually born in a sort of nest under a projecting cliff shrouded in front by dense brush. Sometimes they are born in a cave, not in deep recesses nor in caves with small openings, but in a shallow, wide-mouthed cavity from which the mother can easily scent danger and make her escape. Twice we have found them under the thick, low-hanging branches of a tree and partly covered with leaves. With their leopard-like spots of very dark brown which they wear for the first four months or more, they were barely evident to the casual eye.

Young lions remain with the mother long after they are weaned, in fact they usually stay until run off by a male who wishes to mate with the female. Before the coming of the male the family usually confines itself to a given locality unless disturbed by hunters.

Except in a few cases we have known, the mother lion deserts her young when the dogs draw near, though she rarely travels any great distance from them. After her first dash for safety she takes to a near-by tree and if chased out of that, circles about in the vicinity but does not approach the lair where the kittens are hidden.

It is upon its wits rather than its legs that the mountain lion must largely depend for escape, for despite its amazing speed for the first

hundred yards, it is no runner. Within that distance it can outrun any dog I have ever seen, especially on a downward slope; but after the first exertion its wind fails and it runs a losing race.

As an artful dodger, however, it is unsurpassed. Leaping from rock to rock across deep crevices, climbing to a treetop from which it can jump to an overhanging ledge, or springing from a ledge into a tree below, it is a most difficult creature for dogs to follow. I have seen the lion spring from the earth and land twelve or fifteen feet above in a tree; I have also seen it jump from a branch to the earth fifty or sixty feet below and light on its feet apparently unhurt.

Contrary to the habits of the female and the young ones, the old males travel great distances. On several occasions I have known an old "tom" to cover more than twenty miles in a single night, traveling along the top of a high ridge and crossing over the peaks or highest spots as it reached them. Though the distance traversed may be sixty or seventy miles the animal will invariably return by the same route. In their wandering from one range of mountains to another, these lions often cross the desert in forty or fifty mile stretches, traveling usually by night and lying by day in the shade of a low mesquite or a palo verde. It is easy to discover the runway of a male lion, for it makes scratches under practically every large tree along the route, although the habit of scratching up piles of leaves is not restricted to the males, for the female too does this.

We have learned much about the lion's method of securing its prey. Although it is often accused of hiding on a rocky ledge or in a tree and springing upon some unsuspecting animal below, we find from careful observation of many of its kills that it rarely does this. The usual method is to stalk silently its prey until it is within a few feet of it, when the lion bounds upon its back, gripping the shoulders with the front claws and often fastening the hind claws in the flanks. It then kills by biting the animal through the back of the neck. So swift and sure are its movements that more than one leap is rarely necessary, although we have found traces of two or three leaps and even of its pursuing its prey for some distance; and we have found a few instances where cattle, horses, and large deer have succeeded in shaking the animal off their backs. This, however, is unusual.

Having captured its prey, the lion usually drags it under a bush or tree before eating any part, displaying amazing power in handling an animal. I have seen a horse weighing eight or nine hundred pounds which a mountain lion has dragged twenty-five or thirty feet, as proved

by tracks in the snow. Even more surprising is the fact that it sometimes carries off what it has killed. I have seen both deer and big calves some distance from where the kill had been made, with no evidence of dragging. To do this the lion first turns the animal on its back, picks it up by the brisket, all four feet stricking up in the air, and walks off with its own head held high.

After the lion has gorged itself on the meat, it covers the carcass with leaves, sticks, and rocks, and retires to some nearby spot to "sleep it off." We have found places where rocks weighing as much as fifteen pounds have been piled up against the carcass of a lion kill, and often sticks as large as a man's arm are placed crisscross on top of it. The lion may never return to eat a second time; on the other hand, the animal may come back for a second meal within a few days, or may eat from this carcass at various times during several weeks, sometimes returning to the scene of its crime long after the meat fails to appeal to him. While the lion is rather fastidious about food and rarely eats any but untainted meat, we have, in a few instances, found it eating carrion.

The lion's liking for the meat of the porcupine sometimes leads it into painful experiences, as quills found in the paws testify. No one knows just how it kills porcupines, but signs in the snow seem to show that it hooks them under the chin with its strong claws, turns them over, bites them in the breast, and proceeds to eat all the meat, leaving the skin of the back, quills down, and the intestines rolled aside.

Though exceedingly fond of burro meat, the lion is rarely able to indulge this appetite, for although the supply is plentiful, numbering about fifty thousand of the wild species in Arizona, and although found on the same range as the lion, the sturdy little jackass roams scot-free. From bitter experience the lion knows what a fiend the little creature can be in combat, fighting with terrible teeth, damaging hoofs, and mighty kicks.

Perhaps the least courageous of the larger wild animals, the mountain lion rarely shows fight unless wounded. When captured on the ground, if unhurt, its first impulse is to escape from the dogs. It makes for a tree where it stays until a hunter approaches; then it jumps to the ground and runs for another. After being run out of two or three trees, it is reluctant to leave, for it can not do much running on account of being short-winded. Hanging on with all claws set in the bark of the tree, it refuses to jump even though punched at with a long stick. I have climbed out on a big branch of a tree and sat within six feet of a

lion while I took a snapshot of it, yet apart from hissing and growling it showed no signs of fight.

Although the reactions of mountain lions are generally those I have here set down, sometimes they do exactly the opposite thing. By far the greater number will run for their lives, yet once they know the dogs are after them, there have been a few that showed no such inclination, but fought to their death, and in one case an old male lion deliberately lay in wait for the dogs and killed one and badly wounded another.

It must be conceded, therefore, that there is marked individuality among mountain lions. For instance, note our observations of the young ones. We have taken several litters of them and raised them by hand. There was perhaps one in a litter that was quite amenable and even affectionate. I recall one that was as gentle and docile as any house cat, even after he was grown, yet the others of the same litter were cross, vicious, and never trustworthy. One can never say, therefore, that a mountain lion will do a certain thing; it is a variable creature.

I have yet to see a lion that will measure more than 9 feet from tip of tail to tip of nose. The largest one taken in this state actually measured 8 feet 7½ inches. The average adult male lion, I should say, would measure 7 feet 8 inches, and the average adult female 7 feet. The heaviest lion taken in this state weighed 276 pounds. The average weight of adult male lions would be about 176 pounds, while the average weight of female lions would be about 125 pounds.

U. S. Biological Survey, Phoenix, Arizona.

STUDIES ON THE VARIABILITY OF PLATYRRHINE MONKEYS[1]

By Adolph H. Schultz

[*Plate 27*]

INTRODUCTION

Investigations on the exact degree of variability in mammals are comparatively scarce and new contributions are greatly needed before generalizing conclusions on several important biological problems can be drawn. The literature on variability contains many conflicting views which can only be cleared up by means of additional observations.

It has often been held that domestication in animals and civilization in man lead to increased variability. Darwin first pointed out that animals and plants that have been long domesticated tend to vary more extensively than their wild ancestral forms. This he attributed chiefly to less uniformity of the conditions of life for domesticated than for undomesticated organisms. However, some domesticated animals, such as the house cat, vary no more intensely than many wild mammalian species. On the other hand, such widely diverging forms as occur among domesticated dogs or horses are probably entirely due to artificial selection, and the natural inherent variability of a given breed is not any greater than in many wild subspecies.

Of particular interest to several different sciences is the claim, made, among others, by Lee and Pearson (1897), that civilization has increased human variability. This conclusion would tend to support the old and widespread dogma that man is the most variable creature and that his great variability is only approached by animals under domestication, in which, as in civilization, natural conditions have largely disappeared. Schwalbe (1898) denied the validity of this theory after finding, for instance, that the size and proportions of the skull of the otter, as determined on over two hundred specimens from the limited district of the Alsace, vary just as much as the corresponding characters in man.

It seems most desirable to compare the degree of variability in man

[1] This paper is one of a series of reports on material and data obtained in 1924, in Nicaragua, by an expedition from the Johns Hopkins Medical School. The personnel of the expedition consisted of Dr. A. H. Schultz, Dr. G. B. Wislocki, Dr. E. F. Snyder, and Mr. O. O. Heard. The expenses were defrayed in part by a grant from the Linton Fund of the Johns Hopkins Medical School and by an additional grant from the Carnegie Institution of Washington.

(particularly in civilized races) with that of other primates living in a natural state. Kohlbrügge (1897) has shown that the muscles of monkeys and apes vary at least as much as those in human beings. Furthermore, a study of the papers by Selenka (1898) and by Hrdlička (1907) on the cranial characters of the orang-utan leaves no doubt that the skull of this ape varies quite as much as that of man.

In this paper it is intended to place on record some new data on the variability of two series of monkeys and this particularly for the purpose of testing again the assumption of a higher variability in modern man than in wild primates which is current among writers familiar with human conditions alone.

MATERIAL AND METHODS

The material for these studies was collected by the author in eastern Nicaragua during the rainy season and consists of a total of one hundred and fifty-one howler monkeys (*Alouatta palliata*), fifty-nine spider monkeys (*Ateles geoffroyi*), and twenty-nine capuchin monkeys (*Cebus capucinus*). The last-named series, being too small, will only be used in connection with some few details. Thirty-three of the howler monkeys and fifteen of the spider monkeys, ranging in age from fetal to adult life, were preserved intact in formalin. Of the remainder of these two series only the skulls (in a few cases the entire skeleton) were brought back. Among these skull series there are sixty female and fifty male howler monkeys and twenty-four female and fifteen male spider monkeys, all of which were fully adult. All the howler monkeys were obtained along the middle course of the Princapolka River, between seventy and one hundred miles from the coast, in the low swampy jungle bordering the river. All the spider monkeys were killed in the immediate neighborhood of one camp on the bank of the Yao-ya River, a tributary of the Princapolka, and all within a period of ten days. Both these series must therefore be considered as very homogeneous, all the specimens having been living under ideally uniform environmental conditions. In this material, if anywhere, one should expect a low variability, as compared with that of man, in case civilization with its widely differing diets, occupations, diseases, and the like is really to blame for human variations.

This study is based partly on the proportions in size between various parts of the body and partly on the dimensions and proportions of the adult skull. Only some of the more important absolute and relative measurements for both the outer body and the skull can be discussed

in this paper, but the features selected are sufficient to demonstrate the typical variability of the series. The following technique was made to conform as far as possible to the methods generally employed in physical anthropology.

Measurements on the outer body. (For a detailed description of most of these see Mollison, 1911): 1. Length of tail = base[2] to tip of tail. 2. Length of spine without tail = base of tail to inion (i in fig. 1). 3. Relative length of tail = measurement 1 in percentage of measurement 2. 4. Relative head size = arithmetic mean of greatest length, width, and height (projective distance from ear opening to vertex) of brain part of head in percentage of anterior trunk length (suprasternal notch to upper edge of symphysis pubis). 5. Relative upper limb length = distance from upper edge of caput humeri to tip of middle finger in percentage of anterior trunk length. 6. Relative lower limb length = distance from highest point on great trochanter to sole of foot. 7. Intermembral index = upper limb length in percentage of lower limb length. 8. Forearm—upper arm index = greatest length of radius in percentage of greatest length of humerus. 9. Leg—thigh index = greatest length of tibia in percentage of femur length (from great trochanter).

Measurements on the skull. (For full details see Oppenheim, 1912): 10. Length = supraglabellare (sg. in fig. 1) to most distant point in midsagittal plane on occiput (but not considering the bony process at i in fig. 1). 11. Width = greatest width of brain case over parietals or squamae temporales. 12. Height = distance from basion (ba fig. 1) to midsagittal point on coronal suture. 13. Base length = basion to midsagittal point on naso-frontal suture (nasion or n in fig. 1). 14. Base width = distance between the two points perpendicular over the ear openings on the roots of the zygomatic arches. 15. Face height = distance from nasion to prosthion (pr in fig. 1). 16. Face width = greatest width between the zygomatic arches. 17. Palate width = greatest width between the outer alveolar borders of the molar teeth. 18. Nasal length = greatest length of nasal bones in midsagittal plane. 19. Cephalic index = measurement 11 in percentage of measurement 10. 20. Base index = measurement 14 in percentage of measurement 13. 21. Face index = measurement 15 in percentage of measurement 16. All the absolute measurements are given in millimeters.

The variability of these measurements and indices is expressed by figuring the difference between their minimum and maximum individual values (range of variation) in percentage of their average value (relative range). A still more reliable method, but as a rule only employed to advantage on larger series, consists in calculating the standard deviation (σ) according to the following formula $\sigma = \sqrt{\frac{1}{n}\Sigma e^2}$, e standing for the deviation of a variation from the average, n for the number of cases examined. In order to free the σ from the absolute size of the average of the character for which it has been figured, it is customary to express it in percentage of this average. This percentage value is called varia-

[2] The base of the tail is determined by inserting a pin into the body at the lowest point of the junction of the ilium with the spine.

tion coefficient (C); it furnishes a criterion for the relative variability which takes into account every single variation, in contrast to the relative range which considers only the extremes. The probable error of the variation coefficient, or E (C), indicates the reliability of the coefficient determined. Theoretically there exists an even chance that the true value of the latter, when not figured from a sample series alone, lies within the limits given by this error. The formula of the latter reads $E(C) = \pm 0.6745 \frac{C}{\sqrt{2n}}$ More details concerning these statistical methods can be found, for instance, in the book by Davenport (1904).

VARIATIONS IN BODY PROPORTIONS

Table 1 gives the relative length of the tail during the growth of howler monkeys and of spider monkeys. In both groups the tail at

TABLE 1

Variations in the relative length of the tail (R. T. L., measurement 3 in chapter on technique) at different stages of growth (as represented by the sitting height, S. H.) in the howler monkey and in the spider monkey. For adults only the average, the minimum, and the maximum of this proportion are given

PRENATAL STAGES				POSTNATAL STAGES			
Alouatta		Ateles		Alouatta		Ateles	
S. H.	R. T. L.	S. H.	R. T. L.	S. H.	R. T. L.	S. H.	R. T. L.
48	84.4			181	170.8	198	221.2
50	86.0			189	183.8	201	193.3
68	102.9			197	160.1	204	215.9
95	105.6			230	168.6	216	200.0
130	125.9			242	176.7	232	195.7
135	144.6			253	161.6	279	204.7
137	131.5			261	172.5	310	229.0
140	133.7			269	169.3	318	248.4
142	145.6			326	175.7	427	222.0
161	158.7	178	157.1	10 adults		10 adults	
168	181.9	187	160.3	min.	135.0	min.	174.0
169	191.1	191	175.8	max.	160.4	max.	201.1
170	180.6	195	169.7	aver.	148.6	aver.	190.2

first increases in relative length, chiefly during fetal life, but decreases again during late postnatal growth. Just before birth the tail of *Alouatta* is proportionately longer than that of *Ateles*, but in life after birth this relation is reversed. The figures show at times a tremendous variability; in the spider monkey, for instance, the tail may amount to 169.7 per cent of the praecaudal spine length in a specimen of 195

mm. sitting height, and to 221.2 per cent in another specimen of practically the same size (198 mm.).

Table 2 compares the variation coefficients for the relative tail length in these two series of platyrrhines with those in other primates, for which the figures are given by Mollison (1911). All these coefficients are very high; indeed, in the anthropoids they surpass those for any other body proportions. It is particularly interesting to find that the coefficients of all the monkeys with long tails differ but little from each

TABLE 2

Averages of the relative tail length and variation coefficients of this measurement in various primates. All the figures, except those for Alouatta *and for* Ateles, *quoted from Mollison (1911) (or, in a few cases, calculated from his data). Species names according to Elliot (1913); wherever these differed from those given by Mollison, those of the latter are placed in parentheses*

SPECIES	NUMBER OF SPECIMENS	RELATIVE TAIL LENGTH	VARIATION COEFFICIENT
Pan chimpanse (Anthropopithecus troglod.)	8	13	17.4
Pongo pygmaeus (Simia satyrus)	5	15	17.2
Symphalangus syndactylus	25	7	30.2
Lasiopyga callitrichus (Cercopithecus callitrich.)	9	180	7.8
Erythrocebus patas	12	161	8.6
Pithecus fascicularis (Cynomolgus fascicularis)	14	175	9.9
Papio hamadryas (Hamadryas hamadryas)	10	120	9.8
Papio sphinx (Choiropithecus sphinx)	12	130	7.8
Ateles geoffroyi	10	190	8.0
Alouatta palliata	10	149	7.1
Callithrix jacchus	12	210	6.6

other, ranging only from 6.6 to 9.9, while the higher apes, in which the tail has become rudimentary, have far greater variation coefficients (on an average one of 21.6) than the primates with well-developed tails (average coefficient 8.2). This constitutes a clear example in support of the theory that such structures as, in a given species, have undergone marked changes during evolution vary individually much more than do the same structures in another species in which it has remained but little altered.[3]

[3] Further examples of this relation between variability and evolution have been published by the author in another paper (1926).

Mollison (1911) has compared the variation coefficients of 18 different body proportions in chimpanzee, orang, and siamang with those of corresponding proportions in man. The averages for the apes amount to 5.0, 9.3, and 9.0 respectively and the one for man to 5.0; i.e., the latter is as variable as the chimpanzee but much more constant than the highly specialized orang and siamang.

Table 3 compares the variability of some body proportions in the howler monkey with that of the same proportions in man. For both *Alouatta* and man two individuals with closely corresponding sitting heights were selected as representative samples for each age group. All

TABLE 3

Percentage differences between corresponding proportions in howler monkeys (two specimens of similar sitting height selected as random samples for each age group) compared with those in whites (two individuals for each age group) of corresponding growth stages

INDICES: (NO. 4 TO 9)	RELATIVE HEAD SIZE		RELATIVE UPPER LIMB LENGTH		RELATIVE LOWER LIMB LENGTH		INTER-MEMBRAL INDEX		FOREARM-UPPER ARM INDEX		LEG-THIGH INDEX		AVERAGES	
	Alouatta	Man	Alouatta	Man	Alouatta	Man	Alouatta	Man	Alouatta	Man	Alouatta	Man	Alouatta	Man
Age:														
Young fetuses	1.6	2.4	14.1	6.1	9.4	2.9	4.6	5.1	3.9	1.6	2.1	7.8	5.9	4.3
Older fetuses	13.6	7.1	8.3	2.7	12.2	1.6	3.9	2.3	3.3	3.0	0.8	1.3	7.0	3.0
Newborns	0.4	0.3	6.0	0.4	9.9	4.1	3.8	4.6	5.0	6.0	2.6	1.0	4.6	2.7
Juveniles	7.8	2.9	0.3	3.5	4.7	3.9	3.0	1.3	1.6	1.9	1.4	11.5	3.1	4.2
Adults	1.9	8.0	8.0	1.5	3.4	4.1	4.4	2.6	3.4	1.6	1.9	2.6	3.8	3.8
Averages	5.1	4.1	7.3	2.8	7.9	3.3	3.9	3.2	3.4	2.8	1.8	4.8	4.9	3.6

the juveniles and adults are males and all the cases of man are whites. The difference in a given proportion between the two individuals of one age group and of one type of primate was expressed in percentage of the arithmetic mean of the two values of the proportion. For instance, the two older fetuses of *Alouatta* (both with a sitting height of 140 mm.) have relative head sizes of 54.6 and 62.6 respectively; the difference amounts to 13.6 per cent of the mean of the two individual values. The table shows first of all that the variability in these proportions is at least as great in early as in late growth stages, indicating that variations do not become more pronounced under the influence of postnatal environmental conditions. The average relative difference of all propor-

tions and all ages amounts to 4.9 in *Alouatta* and to 3.6 in man. While too much stress should not be laid on these figures, which are derived only from few random samples, they permit nevertheless the definite conclusion that the relations between different body parts vary fully as much in wild howler monkeys, coming from one small area, as in civilized man.

VARIATIONS IN SKULL MEASUREMENTS

Table 4 is a compilation of the averages and variability of the more important skull measurements and proportions. In comparing the absolute dimensions of the *Alouatta* skull with those of the *Ateles* skull it is apparent that the length, width, and height of the brain case is much greater in the latter than in the former, whereas the measurements of the base as well as those of the face part of the skull surpass in the howler monkey those in the spider monkey. This marked difference in relative size of brain part and of face part between the two types of platyrrhines is readily seen on the midsagittal skull sections of these primates in figure 1. In the spider monkey the phylogenetic increase in relative brain size has occurred in close connection with a marked decrease in the size of the entire masticatory apparatus,[4] which, in turn, resulted in a smaller and less protruding face part of the skull than in the howler monkey. These conditions of the *Ateles* skull resemble in principle those of the human skull. It will be shown later on that the formation of the forehead in *Ateles* also demonstrates an evolutionary tendency which, in some points, seems to repeat what must have occurred in the human forehead. Last but not least, it must be mentioned here that the brain of the spider monkey shows various features in which it approaches the human brain more closely than does any other primate brain (Hatschek, 1908; Kappers, 1924). All this, of course, does not point to any closer relationship between man and *Ateles*, but merely indicates some evolutionary parallels in otherwise widely differing primates.

[4] This shortening of the jaws in *Ateles* is most probably responsible for the fact that in 15 per cent of the specimens the last molars were congenitally lacking, whereas no such case was found among the one hundred ten adult howler monkey skulls with their long jaws. This evolutionary tendency toward the elimination of the last molars is almost as pronounced in *Ateles* as in the higher races of man. These conditions, together with other variations in the teeth of this material, was discussed in detail by the author in a special paper (1925).

TABLE 4

Averages, relative ranges of variation, and variation coefficients (with their probable errors) of skull measurements and indices in howler monkeys and in spider monkeys. The numbers in parentheses in the first column correspond to the number of the measurement in the chapter on technique

MEASUREMENT OR INDEX	ALOUATTA PALLIATA, ADULTS						ATELES GEOFFROYI, ADULTS						AVERAGE C
	Males			Females			Males			Females			
	Average	Per cent range	C±E(C)	Average	Per cent range	C±E(C)	Average	Per cent range	C±E(C)	Average	Per cent range	C±E(C)	
Length (10)	65.3	19.9	3.14±0.21	62.5	12.8	2.66±0.16	79.7	16.3	3.90±0.48	79.6	11.3	3.03±0.29	3.18
Width (11)	51.7	15.5	2.92±0.19	49.6	12.1	3.08±0.19	58.7	11.9	3.48±0.43	58.5	12.0	3.44±0.33	3.23
Height (12)	43.5	9.2	2.74±0.18	42.4	9.4	2.49±0.15	53.1	15.1	3.90±0.48	54.4	20.2	4.13±0.40	3.32
Base length (13)	65.2	15.3	3.02±0.20	58.7	10.2	2.35±0.14	60.4	13.2	3.81±0.47	62.2	9.7	3.17±0.31	3.09
Base width (14)	56.2	19.6	3.36±0.23	50.6	13.8	3.79±0.23	55.6	18.0	5.18±0.64	55.5	16.2	3.93±0.38	4.06
Face height (15)	41.7	16.8	3.40±0.23	36.1	16.6	3.71±0.23	35.5	19.7	5.58±0.60	35.5	25.3	6.57±0.64	4.82
Face width (16)	81.9	17.1	3.25±0.22	69.7	15.8	3.23±0.20	66.1	22.7	6.16±0.76	65.2	12.2	3.97±0.38	4.15
Palate width (17)	38.9	15.4	2.75±0.19	35.9	13.9	2.87±0.18	30.4	9.9	3.42±0.42	30.4	9.9	3.29±0.32	3.08
Nasal length (18)	21.0	28.6	6.48±0.44	19.0	21.0	5.95±0.36	16.5	30.3	7.22±0.89	16.2	30.8	8.14±0.79	6.95
Cephalic index (19)	79.3	16.4	3.03±0.20	79.8	12.4	2.75±0.17	73.8	13.0	3.94±0.48	73.9	15.8	4.20±0.43	3.48
Base index (20)	86.1	14.3	3.07±0.21	86.2	13.3	2.89±0.18	92.0	12.1	3.74±0.46	89.2	10.9	2.67±0.26	3 09
Face index (21)	51.0	16.3	3.73±0.25	51.9	18.1	4.12±0.25	53.7	20.5	4.77±0.59	54.6	23.6	6.15±0.60	4.69
Average		17.0	3.41		14.1	3.32		16.9	4.59		16.5	4.39	3.93

All the averages of the nine direct measurements listed in table 4 are, in case of *Alouatta*, greater in males than in females. In case of *Ateles* these averages are greater in males in only five instances, while for two

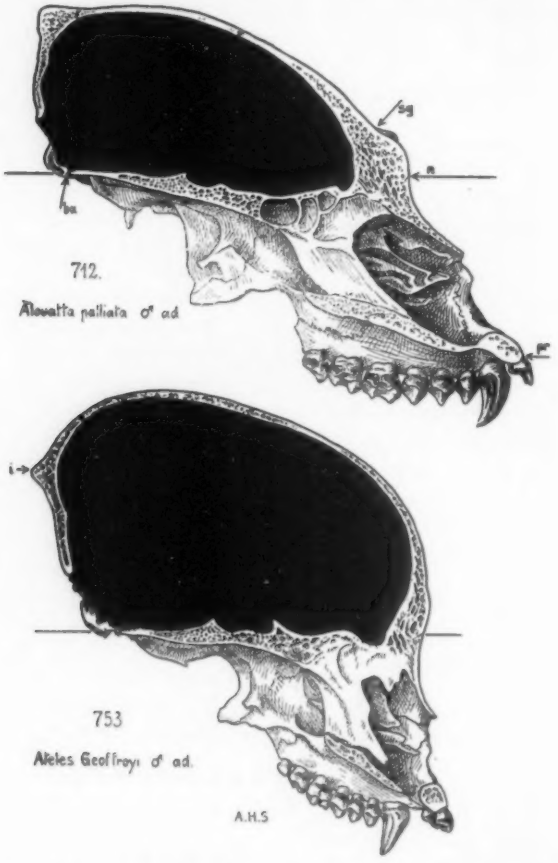

FIG. 1. SKULLS OF ADULT MALE HOWLER MONKEY (ABOVE) AND OF ADULT MALE SPIDER MONKEY (BELOW) CUT THROUGH THE MIDSAGITTAL PLANE

The area of the brain cavity is shown in solid black. Both skulls drawn to the same scale and oriented so that the skull base (n-ba) is horizontal.

measurements they surpass in females those for the males, and in the remaining two there exists no sex difference at all. These differences, when calculated in percentage of the mean between the values for the two sexes, average in *Alouatta* 9.0 and in *Ateles* 1.0; in other words, the corresponding skull dimensions in male and in female howler monkeys differ from one another on an average for 9 per cent of their mean value, in the spider monkey very much less, namely, only 1 per cent. If the differences in favor of the female are given a − sign, the average relative difference in *Ateles* is reduced to −0.3. This renders the contrast between the two platyrrhines even greater, since it can now be stated that the skull of the howler is on an average nearly 10 per cent larger in the male than in the female, while in the spider monkey there exists practically no such sex difference.

The variation coefficients in table 4 permit at least three broad conclusions. First of all, it is at once apparent that they are always higher in *Ateles* than in *Alouatta*, thus indicating that different species of primates may be markedly different in regard to the constancy with which the individuals resemble their type. Another interesting result, gained from a comparison of the variation coefficients in table 4, consists in the fact that the face part of the skull, in both *Alouatta* and *Ateles*, is much more variable than the brain part. The coefficients appertaining to the latter (last column in the table; measurements 10 to 14 and 19 and 20) average 3.35, those for the former (measurements 15 to 18 and 21) 4.74.

A third conclusion forms a contribution to the much contested problem of a difference in variability in the two sexes. The averages of the relative ranges of variation, as well as those of the variation coefficients, are larger for the males than for the females in the howler and in the spider monkey. Oppenheim (1912) has recorded the ranges of variation for 15 different cranial characters in males and in females of series of anthropoids. From these data the following figures were obtained: in orang-utan skulls ten characters varied more extensively in males, five, more in females; in chimpanzee only three of the fifteen characters showed a wider range in females than in males; and in gorilla even only one feature was less constant in the female. There are, therefore, on an average five times as many cranial characters varying more in male than in female apes than those which show a reversed relation. In the anthropoid, as in the platyrrhine primates, the male sex tends to vary more than the female sex. It has been claimed that in man it is also the male sex which shows the greater variability. However, Pearson

(1897) has emphatically denied this, stating that if there is any sexual difference in this respect, it exists in favor of women. The variation coefficients for males and females of various human races and for a great number of cranial measurements and indices given by Martin (1914) and by the author (1917) were found to be larger in women in sixty-four instances and larger in men in eighty-eight instances. This means a ratio in the variability of females and males of 1:1.4 respectively. The author can not therefore agree with the conclusion reached by Pearson, but has to state that in all the primates studied, including man, the male

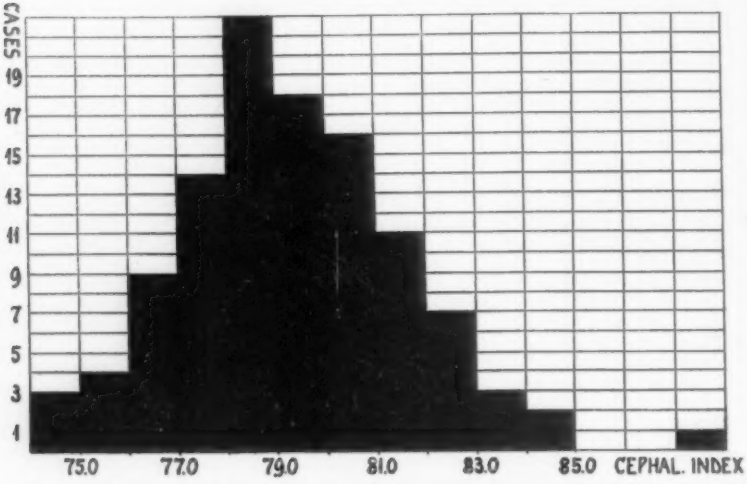

FIG. 2. FREQUENCY POLYGON OF THE VARIATIONS IN THE CEPHALIC INDEX OF ADULT HOWLER MONKEY SKULLS

sex is in general more variable than the female sex. In other mammals the same seems to hold true. For instance, Howell (1924) has given the relative ranges of variation for fourteen different bodily characters in a rodent (*Microtus montanus*) in ten of these characters the ranges surpassed in males those of females and the average of all the relative ranges amounts to 19.7 in males and to only 16.9 in females. It may finally be mentioned here that Montgomery (1897) found that in birds also the males generally exhibit a greater amount of individual variation than females of the same species.

The variability within a species is best illustrated by the so-called

frequency polygons, which are constructed from all the individual variations. The latter become theoretically less and less frequent the farther they deviate from the average, that is, the more extreme they are. If this is not the case, suspicion is justified that the material used does not represent one single species or race. Figure 2 gives this test for *Alouatta* on the example of the length—width proportion of the skull. It is seen that the polygon has only one peak from which the variations taper off to both sides. The isolated high index on the right would most likely be merged with the rest in a larger series.

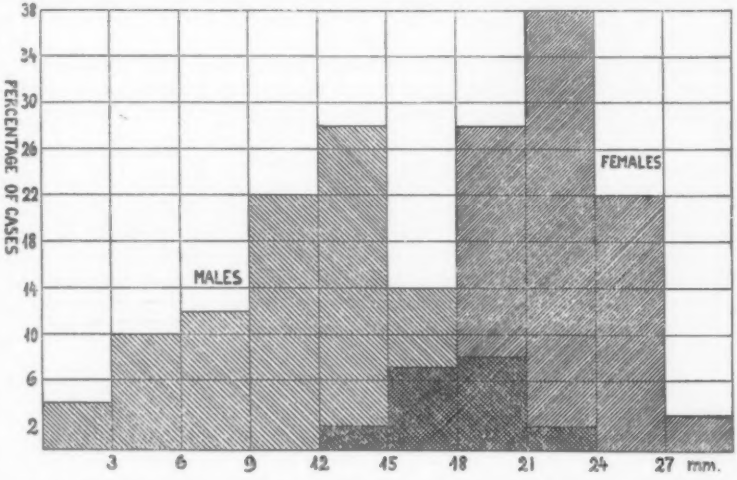

FIG. 3. FREQUENCY POLYGON OF THE VARIATIONS IN THE DISTANCE BETWEEN THE TEMPORAL LINES ON SKULLS OF ADULT HOWLER MONKEYS

Lighter shaded polygon for males, darker shaded one for females, darkest area resulting from overlapping of the two polygons.

A marked sex difference in a character results in a polygon with two apices, as shown by figure 3. This figure illustrates the distribution of the individual variations in the distance between the temporal lines (measured across the point in which the sagittal and coronal sutures meet). It is generally assumed that the stronger the temporal muscles the larger is the surface of attachment they require and, consequently, the higher up are the temporal lines on the skull. It is a well-known fact that in males of most primates the temporal muscles approach each

other on top more closely than they do in the females of the same species, a difference which is nowhere more striking than in the gorilla. Such a sex difference exists also in the howler monkey, in which the temporal lines are anywhere from 0[5] to 24 mm. (average 12 mm.) apart in the male, whereas in the female they are anywhere from 12 to 30 mm. (average 22 mm.) apart. It was attempted to correlate the variations of this measurement in adults of one sex with the size, strength (according to thickness of zygomatic arches), and probable age (as estimated by the closure of sutures and wear on the teeth) of the specimens, but no such connection could be detected. For instance, of the two largest

TABLE 5

Relative ranges of variation and variation coefficients for some skull measurements and indices in adult males of Alouatta *and* Ateles, *compared with those in adult male Swiss (detailed data on the latter were published by the author in 1917)*

	PER CENT RANGE OF VARIATION			VARIATION COEFFICIENT		
	Alouatta	Ateles	Swiss	Alouatta	Ateles	Swiss
Length	19.9	16.3	16.9	3.14	3.90	3.72
Width	15.5	11.9	12.1	2.92	3.48	2.73
Height	9.2	15.1	12.0	2.74	3.90	3.09
Base length	15.3	13.2	13.0	3.02	3.81	3.21
Base width	19.6	18.0	19.5	3.36	5.18	3.70
Face height	16.8	19.7	23.5	3.40	5.58	6.20
Face width	17.1	22.7	17.0	3.25	6.16	3.56
Cephalic index	16.4	13.0	22.5	3.03	3.94	1.24
Base index	14.3	12.1	20.3	3.07	3.74	4.12
Average	16.0	15.8	17.4	3.10	4.41	3.51

male skulls one had the temporal lines 20 mm. apart, the other one only 1 mm. The author is convinced that in the same sex the height to which the temporal muscles extend on the cranial vault varies in different individuals independently of the size or strength of the specimens. In passing, attention might be called to the fact that in regard to this character also the females vary less than the males.

[5] In an occasional specimen of male howlers the right and left temporal lines meet in the midsagittal plane, but they have never been found to form a sagittal crest, as happens in rare cases of male capuchin monkeys (it was found by the author in one male adult *Cebus flavus* and in two male adult *Cebus macrocephalus*). In *Ateles* the temporal lines never meet on top of the skull.

Table 5 compares the variability in the two series of monkeys with that in man. The average relative ranges of variation in the former fall very little below that in the latter and the average variation coefficient for man is somewhat higher than that for *Alouatta* but considerably smaller than that for *Ateles*. From this it can be concluded that the general variability of the skull, like that of the proportions of the body, is practically as great in primates, living under strictly uniform conditions and under the laws of natural selection, as in modern civilized man.

VARIATIONS IN THE SHAPE OF SOME CRANIAL STRUCTURES

Variations in the shape and detailed configuration of some parts of the skull do not lend themselves very readily to exact measuring. It is preferable to demonstrate these variations by accurate drawings. The

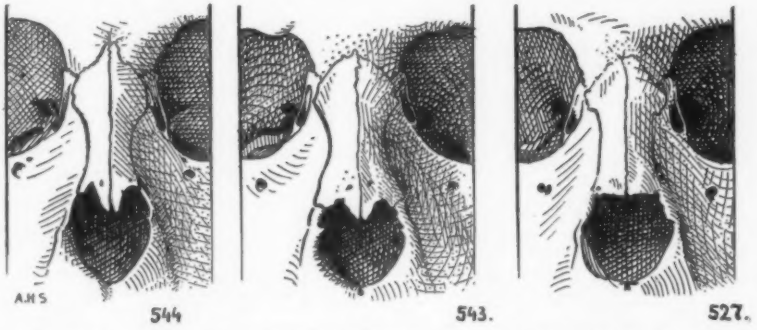

FIG. 4. VARIATIONS IN THE SHAPE OF THE NASAL BONES OF ADULT MALE HOWLER MONKEYS

length of the nasal bones was found to be extremely variable in the howler as well as in the spider monkey (table 4). It is not surprising, therefore, to learn that the shape of these bones also fluctuates in different individuals within widely separated extremes. Figure 4 shows three radically differing examples of nasal bones, all of which belong to howler monkeys of the same sex, locality, and approximately the same age.

In arranging the series of adult female *Alouatta* skulls according to the shape of the posterior portion of the palate the variations grouped themselves without any noteworthy gap between the two extremes pictured in figure 5. It suffices to mention here that the other series,

when studied in an analogous way, showed a range of variation in this feature which fully equaled that illustrated in figure 5.

No variations among the *Alouatta* skulls were more striking than those in the facial profile. Figure 6 shows how widely the latter may differ

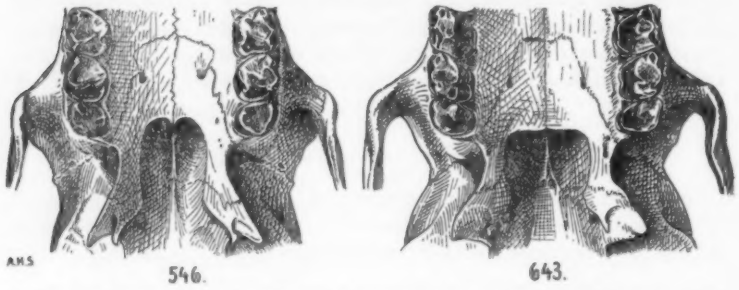

FIG. 5. EXTREME VARIATIONS IN THE FORMATION OF THE POSTERIOR PART OF THE HARD PALATE IN ADULT FEMALE HOWLER MONKEYS

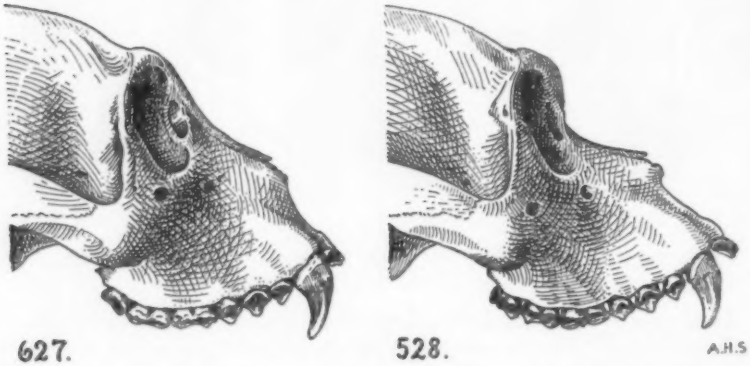

FIG. 6. EXTREME VARIATIONS IN THE FACIAL PROFILES IN SKULLS OF ADULT MALE HOWLER MONKEYS

in the various specimens. In some the line from the glabella to the lower end of the nasal bones may be nearly straight, while in others it is extremely concave. The author is unable to suggest any particular cause for these variations. The extremes in figure 6 happen to have been obtained in the same locality and are therefore certainly not

representatives of different local races. The interorbital region appears to be pushed forward in one and pushed back in the other, giving rise to what may be termed a "Roman" nose and a "pug" nose. Again it should be stated that the two examples in figure 6 are not isolated (perhaps even pathological) cases, but are merely the ends of a series of perfectly normal variations which bridge completely the gap between the extremes.

As a final example of the many and marked variations in these monkey skulls, the formation of the forehead in *Ateles* will be briefly discussed.

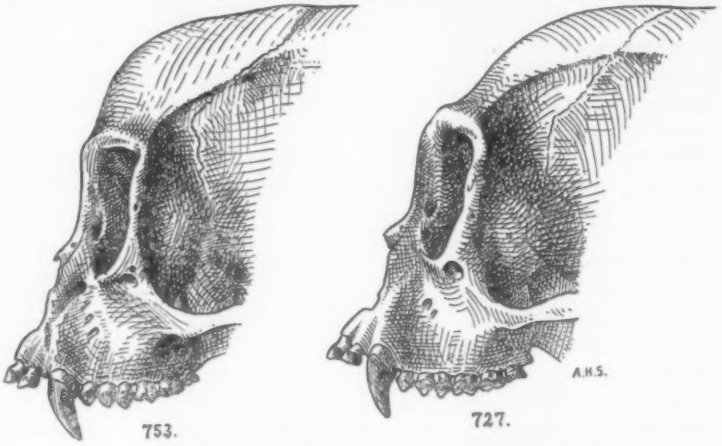

FIG. 7. EXTREME VARIATIONS IN THE FORMATION OF THE FOREHEAD IN SKULLS OF ADULT MALE SPIDER MONKEYS

Figure 7 shows at a glance the astounding difference which may occur in this feature in different individuals. Cases in which one can speak of a real forehead, in the sense in which the term is applied to man, are not rare (see left picture in fig. 7 and lower picture in fig. 1.). In the same troupes of monkeys which contained individuals of the latter type were also found others with such low retreating foreheads as that shown on the right of figure 7. If, by a rare chance, only the extremes of the variations in the development of the forehead had been obtained without any of the connecting intermediate degrees, one might almost have been led to propose a new subspecies. The two cases in figure 7 illustrate strikingly how widely normal variations may fluctuate with-

out our being able to say that they are due either to different environmental factors or to any particular form of selection. With such examples as these, it seems extremely doubtful that civilization could have produced any wider range of variation in man.

In fetuses of all the primates the frontal region is relatively higher and much steeper[6] than in adults. This typically prenatal condition disappears, as a rule, soon after birth. In the infantile *Cebus*, *Alouatta*, and *Pithecus*, for instance, the forehead, as pictured in figure 8, retreats immediately above the orbits. In the infantile *Ateles*, however, the fetal formation of the forehead is still present (see fig. 8), constituting a marked contrast to the other primates of corresponding ages. From these findings it becomes evident that the high forehead of some adult spider monkeys can be regarded as a retention of a fetal condition. The degree and duration of this varies in different individuals; while in all spider monkeys the fetal type of forehead persists longer than in other monkeys, it is retained throughout life only in a certain percentage of the cases, which, no doubt, must be regarded as progressive variations.

ASYMMETRIES

While so far this paper has dealt with variations in different individuals, a few brief notes must be appended here in regard to independent variations in the two halves of the same body, that is asymmetries. Mollison (1911) has shown that asymmetries in the length of the limb bones are very common in all primates. In platyrrhines there exists apparently no clear preference of one side over the other, such as in man, in whom the right upper limb is most frequently longer than the left, and the left lower limb longer than the right. In the platyrrhines the two sides in general seem to be favored with equal frequency. These results can be confirmed by the author, who has measured the long bones in a small series of adult New World monkeys (including some specimens of *Cebus capucinus*). Asymmetries were present in this material without any exception; they amounted on an average to 0.82 per cent of the measurements of the shorter bones. The most asymmetrical parts of the entire skeleton were found to be the clavicles, which differed on the two sides on an average for 2.1 per cent of the shorter clavicle, the left one being just as frequently the longer as the right one. Asymmetries on the outer body of platyrrhines are also a

[6] The high and bulging forehead of primate fetuses is shown, for instance, in the drawings of cleared specimens of *Alouatta* and of *Colobus* in previous papers by the author (1921, 1924).

FIG. 8. SIDE VIEWS OF SKULLS OF INFANTILE MONKEYS, FROM TOP TO BOTTOM: ATELES GEOFFROYI (No. 765, AUTHOR'S COLLECTION), CEBUS CAPUCINUS (No. 331), ALOUATTA PALLIATA (No. 577), PITHECUS RHESUS (No. 208).

All reduced to the same scale. Note the much higher forehead (as measured from the upper edge of the orbit) in the first than in the other three primates.

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very common finding. The length of the right and left foot, for instance, differed in the majority of the specimens examined. The most marked asymmetries occurred in the outer ears, one at times being more than 10 per cent longer than the other. All these asymmetries are perfectly normal, ranging in degree from nearly complete identity to a discrepancy on the two sides of 11.8 per cent of the smaller of the two measure-

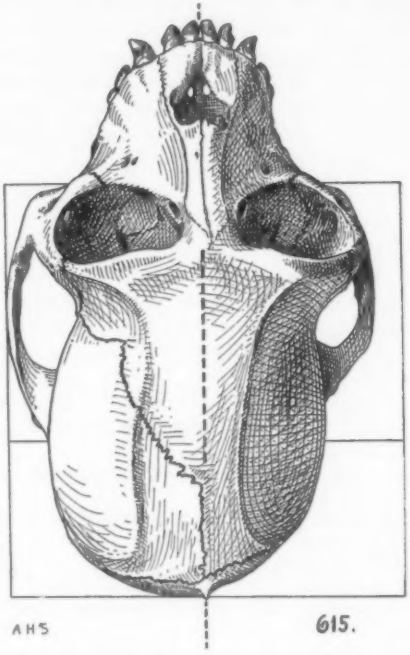

FIG. 9. VIEW FROM ABOVE OF ASYMMETRICAL SKULL OF ADULT FEMALE HOWLER MONKEY

The coronal suture on one side is obliterated

ments in case of the ear width of an adult spider monkey and the ear height of an adult capuchin monkey. These are manifestations of a certain independent variability in the two halves of the body; they are not due to slightly differing functions on the two sides since asymmetries can be very pronounced even in very young fetuses.

Of a fundamentally different nature are the asymmetries which are the consequences of some pathological cause, such as described by Howell (1925) or such as the cases discussed in the following. Among the adult female howler skulls of the writer's collection there are four specimens in which the coronal suture on one side (two times on the right and two times on the left) was prematurely and completely obliterated, leading to such marked abnormal asymmetry as is shown in figure 9. Due to the early closure of the suture bone growth is retarded on the affected side which results in a condition well known in man under the term of plagiocephalus. All the four cases are female, all come from the same limited area, and in every one the asymmetry is as pronounced as in the specimen pictured in figure 9. In these skulls the glenoid fossa and the auditory meatus of the side with the obliterated suture lie far in front of these structures on the normal side. The brain case on the latter side is not only broader and longer than on the abnormal side but it is also considerably higher.

By these scattered notes on the variability in some primates the author hopes to have shown at least how unstable some species of wild animals can be and, hence, how careful one should be in generalizing from a study of a few specimens alone.

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Laboratory of Physical Anthropology, Johns Hopkins University, Baltimore.

NOTES ON THE BIG GAME OF AFRICA AND ITS PRESERVATION

BY HERBERT FRIEDMANN

In the JOURNAL OF MAMMALOGY for May, 1926, there appeared an article by Henry R. Carey entitled "Saving the Animal Life of Africa—A New Method and a Last Chance," which interested me greatly, as I had just recently returned from over a year's stay in Africa, a good part of which time was spent in the big-game districts. The two things that impressed me most in Mr. Carey's article were the author's commendable enthusiasm for the cause of conservation and his lack of first-hand knowledge of African game and conditions. Insufficient knowledge coupled with great enthusiasm is frequently apt to mislead a man, especially when the enthusiasm is directed not towards the acquisition of more data but towards acting on the information already at hand.

With his desire to save the large mammals of Africa I am in complete sympathy, but it is his proposed method and some of his statements about the present status of game and game preservation to which I take exception.

Mr. Carey's paper opens with a brief mention of the buffalo in North America in which he seems to feel that indiscriminate wholesale shooting was the sole cause of their decimation. He forgets that the change in external conditions coincident with the settling of the country and the westward march of civilization was as important a factor as was the actual shooting, deplorable and inexcusable as the latter was. The comparison with South Africa is not far fetched, but to extend it to East Africa is entirely wrong for the people there have profited by the experience of the Boers. The large size of the bag allowed on a big game license (which costs a visitor $500 in Kenya Colony) is not out of keeping with the abundance of game and wherever any species of large game animal is found to be scarce it is locally protected.

At this place I would remark on a few points mentioned by Mr. Carey.

On page 76 he writes that, "in 1910, hippopotami were abundant on the Tana River. They have vanished in 15 years!" It may be that they are not as abundant as they were in 1910 but they are certainly not uncommon in the upper stretches of the Tana River today. I write this on the authority of many hunters whom I met in Africa as I have not been on that river myself. My personal experience with hippo was limited to the following places: the Umfolozi in Zululand, the Zambesi River in Rhodesia, the Tsavo River and Lake Naivasha in Kenya Colony, and Lake Victoria and the Victoria Nile in Uganda. In all these places (with the exception of the Tsavo River which is a rather small stream), hippos were common enough to satisfy the keenest conservationist. None of these places is in a game reserve except Lake Naivasha, where the hippos are protected. Not many of the hunters who go to Africa for sport shoot hippos, as the huge beasts do not make attractive trophies and require special licenses and extra fees.

As with the hippo, the giraffe is also treated as a fast disappearing animal. On page 76 Carey writes that, "although herds of giraffe still flourish in remote districts, yet in the opinion of a naturalist writing in 1907, 'this wonderful and harmless animal is being completely annihilated . . . . the day can not be far distant when the beautiful eyes of the last 'Twigga' will close forever in the desert.'" In Tanganyika Territory and Kenya Colony I found the giraffe far commoner than I anticipated and from what I heard from hunters in Rhodesia the animal is plentiful in suitable places. The giraffe is not only protected by law, but in Kenya Colony is strongly protected by public sentiment. Comparatively few hunters (except hunters collecting for museums) shoot giraffes as far as I could find out from extensive

inquiries in Kenya Colony. Most big game hunters are not cold-blooded butchers, as some conservationists imagine, but are as capable of sympathy and sentiment as anyone else. I once talked to a man who had shot a giraffe some time before and he admitted that he would not care to do so again. The plea of the soft brown eyes, the graceful and inoffensive limbs, apparently overcame the desire to kill in this man and it was with more remorse than pride that he contemplated his trophy. However, it must be admitted that all hunters are not alike.

One of my pleasantest memories of Africa is of a sunrise in April near Taveta, about thirty miles from Kilimanjaro. The first rays of the sun used to strike the snows of Kibo (the higher of the two peaks of the mountain) and transform them into a delicate pink against the dusky sky while the lower reaches of the mountain and the tropical plain were still concealed in darkness. One morning as I looked out of my tent towards the mountain the heads of two giraffes serenely contemplating me from over an acacia tree were silhouetted against the rosy cone of Kibo and as day approached the silhouette gradually changed into colored reality. For over twenty minutes those two stood there watching me, and when they finally ambled off I left, thankful that public opinion was in their favor and would preserve them for future travellers to gaze upon.

For those who despair of the future of Africa's great mammals I submit the following list of big game I saw myself during thirteen months in Africa. I was not looking for game as my work was purely ornithological and I never chose any locality in which to work for any reasons other than the occurrence of certain birds. The localities are purposely not given and the totals for each species (in many cases only approximations) are the totals for the entire trip, which covered parts of the following countries: Union of South Africa, Bechuanaland, Southern Rhodesia, Northern Rhodesia, Portuguese East Africa, Tanganyika Territory, Kenya Colony, Uganda, and the eastern border of the Belgian Congo.

Aard-vark 3 (and many burrows)
Elephant 100
Black rhinoceros 12 (and abundant fresh signs)
Grant's zebra 20,000
Grevy's zebra 30
Burchell's zebra 11
Hippopotamus 25
Wart hog 4
Giraffe 350
Buffalo 40
Eland antelope 50
Greater kudu 7
Lesser kudu 2
Thomson's gazelle 5,000
Grant's gazelle 150
Fringe-eared oryx 65
Oribi 25

Springbok 16
Blesbok 4
Lechwe 6
Uganda kob 1
Impalla 1,000
Duiker (sev. forms) 75
Gerenuk 30
Waterbuck 4
Sitatunga 2
Roan antelope 3
Sable antelope 2
Steenbok 25
Dik-dik 30
Brindled gnu 5,000
Hartebeest (sev. sp.) 15,000
Lion 12 (and abundant fresh signs)
Leopard 1
Cheetah 1
Jackal 75
Spotted hyena 9
Serval cat 1
Chacma baboon 500
Colobus monkey 8
Vervet monkey 16

Mr. Carey quotes largely from Schillings and others but not from any publication later than 1910. Mr. Lang's East African experience was in 1906 and 1907 so that even he is out of date, for most of the present rulings in East Africa came into operation after 1910. As an example the following may suffice. In July, 1924, shortly before I left for Africa I told Mr. Lang I was going to South and East Africa and asked him for advice in choosing a rifle. I told him I was not going to shoot game but wanted a rifle for protection and he advised me to get a Winchester .351 automatic repeater. Knowing that he had been in East Africa and was therefore familiar with the game laws of that country, I took his advice; but when I got to Kenya Colony the rifle was immediately confiscated by the customs authorities as automatics are now illegal and have been for some time in that country.

Mr. Carey writes on page 78 that ". . . . unprejudiced naturalists assert that even the British reservations are anything but perfect game sancturaries . . . ." This is true in an absolute sense but relatively it is not. When we consider the small white population of Africa north of the Limpopo River and south of the Sahara and the enormous area involved we can hardly expect the game reservations to be adequately policed. But if we compare the game conditions in a place like Kenya Colony, with its average of one white man per 25 square miles (and most of the whites concentrated in a few spots) with those in any part of the United States of like extent (250,000 sq. miles) the percentage of white population engaged in protecting the game will be found to be greater there than here. It is also likely that the percentage of hunters is larger there than here, but the British are making great efforts to protect the game. Fortunately game preservation has become of commercial importance in East Africa as the local people realize that most of their highly profitable tourist trade is with big-game hunters who

come to that far-off corner of the world solely on account of the game. They are not going to sit by and watch one of their principal sources of revenue disappear under their very eyes. Individuals may and do at times look for excuses and apply for permission to shoot animals protected by law but what usually happens is that one of the game rangers is appointed to do the shooting, which takes away most of the desire on the part of the applicants. Inasmuch as there are no white settlements in any of the game reserves the sound of rifle fire is heard in protected land only rarely. Near settlements there is, no doubt, much illegal shooting being done under the pretext of protection of stock, crops, and human life.

On page 78 we read that reservations, " . . . . in the British Colonies . . . are not closed to *all* persons. In one important British reserve, moreover, the Southern Game Reserve of Kenya Colony, every time there is a drought, the natives and their cattle, which are privileged, are apt to take possession of the watering places, thus driving the game from the reserve to the outside district, where they are foredoomed." Whether or not the natives still have this privilege I can not say but in times of extreme emergency the natives should be given consideration over the game. From a biological point of view the natives are certainly as interesting as the game. Anyway no amount of legislating could keep the natives from trying to save their cattle in time of drought.

A word about "commercial tours." It seems that Mr. Carey feels it is a great calamity that Cook's tourists now go to the Victoria Falls. He supposes that there is now, " . . . . a trail of peanuts and chewing gum from the ocean to Victoria Falls." It would be a greater calamity if that great cataract were to remain inaccessible to all but a few explorers. I was there less than two years ago and found neither peanuts nor chewing gum, but did find that grand spectacle entirely unspoiled. The Rhodesian government is seeing to it that it will never be spoiled.

If the average tourist were to see a little of the wild life of Africa, the number of supporters to the cause of game preservation could easily be increased.

What is needed at present is more detailed knowledge of local conditions in all parts of Africa. To go to a legislative council, as Mr. Carey suggests, with a petition founded on insufficient and somewhat incorrect data would be enough to turn that council against it if the members of that tribunal were to make any personal inquiries into the matter.

That the big game of Africa needs protection is quite true but those who would work for this cause should avoid jumping to extremes in their ideas.

Bussey Institution, Harvard University,
Forest Hills, Boston, Massachusetts.

AFRICAN GAME CONSERVATION THROUGH THE LEAGUE OF NATIONS (A REPLY TO DR. HERBERT FRIEDMANN)

By Henry R. Carey

Thoreau said, "It takes two sides to tell the truth." As this is unquestionably true, if my unknown friend Doctor Friedmann and I keep on discussing long enough the genial and patient readers of the Journal of Mammalogy are likely to get hold of some real nuggets of valuable information.

Doctor Friedmann's argument against my plan for supervising African game conservation by a Permanent Game Commission of the League of Nations boils down to this: (1) African game needs protection, but not as badly as Mr. Carey thinks it does, therefore (2) I "take exception to" his "proposed method" of saving the game, as he is "jumping to extremes."

At step 2, Doctor Friedmann slaps the stop signal across the road, and halts all the traffic. At the same point, I desire to go on and find a remedy. For we all agree, including Doctor Friedmann, that "the big game of Africa needs protection."

I agree with Doctor Friedmann that "insufficient knowledge coupled with great enthusiasm is frequently apt to mislead a man." I suspect, moreover, that Doctor Friedmann's knowledge of international law and the League of Nations is neither first-hand nor up-to-date enough to justify his stating with authority that the League plan of saving African game is a method which "jumps to extremes."

On the other hand, I can claim some slight knowledge of both international law and the League, having studied them rather carefully for a good many years. Nor did I formulate my plan without first consulting experts both on international law and on the League, all of whom encouraged me to develop my idea further. What really troubles Doctor Freidmann is his struggle with a new idea in government. The League is in Africa to stay. The International Sleeping Sickness Commission

of the League met at Entebbe, Uganda, early last June (1926). The Mandates Commission has already shown remarkable results in promoting the welfare of African natives. There is a vivid contrast between their condition in Tanganyika (British, mandated) and their status just north in Kenya (British, without a mandate.)[1] There is no valid reason why League protection should not be extended to animals. It is logically the next step, other conservation methods having proved anything but perfect.

It is perhaps true that I have unwittingly exaggerated the plight of African animals in one or two cases. But that does not change the fact that many species need additional protection, and that protection should be sought not through one, but through *all* possible channels. The fate of my plan will depend, not upon whether Doctor Friedmann or anyone else thinks game conditions in Africa are *very* serious, or merely *rather* serious, but upon whether the League officials eventually decide to encourage the scheme.

Taking up Doctor Friedmann's points in detail, of course one realizes that the extermination of the American bison was due in part to changes in physical conditions due to settlement. Anyone who has seen "The Iron Horse," a film which is historically correct on major points, can not fail to understand that.

One reason why it is possible to compare the slaughter of game in South Africa with the possibilities in East Africa is that there are many Boers in East Africa, who constitute (according to the very latest information) a great menace to the game.

As to the disappearance of hippos from the Tana River in fifteen years, I refer Doctor Friedmann to my authority Carl Akeley,[2] who writes, "So much for African Hall as biography. By the time it is completed it will be more than that. It will be history. Many of the animals re-created there will have been exterminated, others will be changed in spirit and in habit by contact with civilization . . . . As late as 1910 I casually counted two hundred hippos in a journey along the banks of the Tana River, their age-old habitat. In one herd at that time I saw as many as forty-seven. Now Martin Johnson, who is in Africa for the purpose of taking pictures of wild life, writes me that the hippos are no longer there." As against this evidence from Mr. Johnson, Doctor Friedmann places his hearsay.

I am very glad to hear that the slaughter of giraffes is not as general

[1] See League of Nations News, June, 1926, p. 9.

[2] See The Mentor, January, 1926, p. 20.

as I had thought. That is excellent news, but it is not a reason for dropping plans for greater game protection all around.

Doctor Friedmann's list of animals seen in thirteen months in Africa would be more impressive did he furnish us the means of comparison with a similar list made five or ten years earlier. No one denies that there are still thousands of animals in Africa. Practically everyone agrees, however, that their numbers are rapidly decreasing. If Doctor Friedmann, wandering over the American plains in 1860, had seen a herd of ten thousand bison, he would have been equally optimistic, and equally wrong in being optimistic. Extermination is relative. One can form no estimate of it by taking a census at a single point of time, without comparison with other periods.

In support of my statement that "even the British reservations are anything but perfect game sanctuaries," I again quote Mr. Akeley, who wrote in 1925,[3] "In all the British Colonies there are great game reserves, but these reserves are not absolute sanctuary. Someone is always looking for an excuse to get in with a gun, and too often succeeds in doing so."

Of course, conditions are in some regions better than they were fifteen years ago, but progress in game protection is not likely if we look only at the bright side of the picture. While my information from a leading conservationist in Kenya (received April, 1926) shows considerable improvement in conservation, it also shows that $250,000 worth of ivory, illegally possessed in Kenya, is annually smuggled into Italian Somaliland; that probably more rhino horn than ivory follows the same course; that the Kenya government can do very little because of lack of funds *and the apathetic state of public opinion;* that the Italian government refuses to coöperate; that in all probability "the death knell of these great herds has sounded;" and that the present staff of the Kenya Game Department consists of *one man to take care of 250,000 square miles!* I doubt very much, therefore, whether Doctor Friedmann is correct in saying that "the percentage of white population engaged in protecting game will be found to be greater there [Kenya] than here," or that the British sanctuaries are relatively water-tight. Evidently my informant in Kenya does not think so, for he strongly recommends a minimum of six wardens instead of one!

Finally, I suggest that Doctor Friedmann should read the recent writings of such men as Carl Akeley, A. Radcliffe Dugmore, and Capt.

[3] The Mentor, January, 1926, p. 49.

Keith Caldwell, all three of them now or very recently in Africa, and all three so thoroughly dissatisfied with game protection even in British Africa that they are giving their time to the thankless task of rousing public opinion to do better. If game protection is satisfactory, why are the great museums hastily securing groups before, as they say, it is too late?

One can not escape the ugly facts, nor dismiss them by the simple statement that these writers are alarmists. And remember that they are writing mostly of British territory, where conservation is at its best. It is well known that conditions in Spanish, Italian, and Portuguese colonies in Africa are less favorable to the animals. An official of the U. S. Biological Survey wrote me this month (July, 1926) that he does not know what, if anything, has been accomplished by Italy, Spain, or Portugal in enforcing the Game Convention of 1900 in Africa.

Philadelphia, Pennsylvania.

NOTES ON MUSTELA CAMPESTRIS JACKSON, AND ON THE AMERICAN FORMS OF LEAST WEASELS

By Myron H. Swenk

In 1880, Dr. Samuel Aughey, then Professor of Natural Sciences in the University of Nebraska, wrote concerning the weasels to be found in the state of Nebraska as follows: "The weasels, however, are abundant, there being at least seven species within the state. The most abundant are the Common Weasel (*Putorius noveboracensis*), the Long-tailed Weasel (*P. longicauda*) and the Common Mink (*P. vison*). Those less frequently seen are the Least Weasel (*P. pusillus*), the Small Brown Weasel (*P. cicognanii*), the Little Black Mink (*P. nigrescens*), and the Black-footed Ferret (*P. nigripes*)" (1, p. 119).

In 1901, when the writer began collecting data on the mammals of Nebraska, he soon encountered this statement by Aughey, and of course attempted to evaluate the records contained therein. Aughey, so far as is known, left no specimens of weasels representing the seven species that he accredited to the state of Nebraska, but he obviously based all of his names and identifications upon the treatment of the genus *Putorius* in Baird's "Mammals of North America" (2, pp. 159–183), which made the harmonizing of most of his species with the more modern (1896) treatments of the group by Bangs (3) and Merriam (12)

a matter of but little difficulty. Passing over the minks (subgenus *Lutreola*) mentioned by Aughey, *P. vison* and *P. nigrescens*, which names, as was shown by Banks in 1896 (4), represented merely individual and not specific, or even geographic, variation, and also easily identifying Aughey's "Black-footed Ferret (*P. nigripes*)" with the characteristic plains mammal still bearing that name (subgenus *Putorius*), there remained the records of four species of typical weasels (subgenus *Mustela*) to be thus harmonized. His long-tailed weasel (*P. longicauda*) was undoubtedly our common plains species still bearing that name; but what the weasels were that he identified as *P. noveboracensis*, *P. cicognanii* and *P. pusillus* constituted something of a mystery.

Especially mysterious was the identification from Nebraska by Aughey of the "Least Weasel (*P. pusillus*)," a species characterized by Baird as only about seven inches long, without a black tip to the short tail and with the upper parts dark, almost liver brown. One could not imagine the long-tailed weasel in any sex, age or pelage agreeing with that diagnosis; yet there was no reason to question the entire honesty of Aughey's listing the species as a Nebraska mammal. The mystery began to be cleared, however, in 1905, when on September 12 the writer visited his friend Mr. Louis Sessions, then an undertaker and taxidermist at Norfolk, Madison County, Nebraska, and was shown a specimen of a very small weasel, obviously a female (measurements from the specimen: Length, 187 mm.; tail, 28 mm.; hind foot, 22 mm.); that had been killed by a cat a few weeks before (in August, 1905) and mounted by Mr. Sessions for his collection. Mr. Sessions stated that he remembered of another similar specimen having been taken at Norfolk many years before, and that these two examples were the only specimens that had come to his notice in forty-five years of activity as a nature student and taxidermist in that locality. Subsequently, Mr. Sessions very generously presented the writer with the mounted specimen, and it is now in his collection. In the writer's "Preliminary Review of the Mammals of Nebraska" (18, p. 75), published three years later, he identified this specimen with Aughey's "Least Weasel (*P. pusillus*)" under the new name given to the little animal by Bangs in 1896, *Putorius rixosus*.

The writer immediately began to try to secure additional Nebraska specimens of this little weasel, especially as the Norfolk specimen did not agree exactly with Bangs' diagnosis of *P. rixosus*, having not only the inside of the toes white, but the toes of both feet wholly white, thus indicating the possibility of being a distinct form. But additional

material was very slow in coming to light, and the next specimen found came in the beautiful wholly pure white winter pelage, which gave no assistance on this point. This second specimen was caught at Trumbull, northeastern Clay County, in November, 1911, as it ran away from under a corn shock when the latter was moved. It was killed, and was mounted by Mr. H. F. Warren, a nurseryman and taxidermist of Trumbull. This specimen, obviously a female, was evidently considerably smaller than the Norfolk specimen, measuring from the mounted specimen as follows: Length, 182 mm., tail, 21.5 mm.; hind foot, 19 mm. Mr. Warren subsequently disposed of this specimen to Mr. A. M. Brooking, a grain dealer and taxidermist of Inland, near Hastings, in Clay County, in whose collection it is now preserved.

While the writer's search for additional specimens of the Nebraska least weasel continued, his goal was anticipated in 1913, when Mr. Hartley H. T. Jackson, of the Bureau of Biological Survey, described the Nebraska form of least weasel as a new species, *Mustela campestris*, from a single type specimen in summer pelage from Beemer, Cuming County, collected April 18, 1911, by Grover Sharp (10, p. 124). Beemer like Norfolk, is in the Elkhorn Valley, being about thirty miles to the east of Norfolk. So far as the writer is aware, this type specimen remains unique in the United States National Museum collections, and no subsequent records of this little weasel have been published anywhere. This specimen measured, according to flesh measurements of the skin by the collector: Length, 184 mm.; tail vertebrae, 32 mm.; hind foot, 19 mm. In describing the species Mr. Jackson regarded the type specimen as "judging from cranial characters, undoubtedly a male," although the animal was sexed as a female by the collector. Comparison with the measurements of undoubted males which are now before the writer shows that the type is too small to be a male, but corresponds well in size with small female specimens, and he has no hesitancy in believing that the collector sexed his animal correctly. The rarity of this little weasel in the Elkhorn Valley is further attested by the fact that Professor Lawrence Bruner did many years of active field work about West Point, Cuming County, a few miles down the river from the type locality, and yet never encountered this species.

The three specimens of the *Mustela campestris* of Jackson known in 1913 being obviously all females, the writer was very desirous of discovering the male, which by analogy should be a considerably larger animal. The first success in this quest came in March, 1916, when a least weasel skin was received by the Lincoln Hide and Fur Company

at Lincoln. It had been sent in with some other furs from Chapman, Hamilton County, by Mr. Fred Nickel of that place, and was recognized and picked out for the writer by Mr. Edward Wallace, a taxidermist associated with the fur company at that time. The fact that, although thousands of weasel skins were secured by this firm from eastern Nebraska and adjacent states, and north into Canada, this was the only least weasel skin in the entire lot, which was carefully gone over by Mr. Wallace, is additional evidence of the general rarity of this animal. The specimen is in the white winter pelage, with only a few brown hairs showing on the crown, over the left shoulder and in the middle of the rump, while there are perhaps a dozen black hairs in the tip of the tail. The writer purchased this skin through Mr. Wallace, and when carefully made up it measured in the skin: Length 244 mm.; tail, 36 mm.; hind foot 27 mm. This, the writer felt sure, was the adult male *Mustela campestris*, but unfortunately there was no accompanying skull. Correspondence with Mr. Nickel in the vain hope of securing the skull brought out the fact that the weasel was trapped on his farm in a muskrat runway on March 1, 1916.

Scarcely had the writer's elation at the securing of this male specimen subsided when a remarkable discovery was made of a colony of *Mustela campestris* near Inland, Clay County, Nebraska. The first clue to this colony was secured on the morning of March 22, 1916, when a specimen of this little weasel (the fifth) was found along the Burlington Railroad track one mile east of Inland by some section men, it having been killed by a train. It was turned over to Mr. A. M. Brooking, who kindly forwarded it to the writer. Unfortunately, the skull was badly crushed. It was an adult male in transition pelage, and the writer's measurements of it in the flesh were 225–32–28 mm. Several days later another specimen was received in the flesh from Mr. Brooking, and was sexed, measured and made up by the writer. It had been killed on April 2, 1916, by Mr. William Peters, in a field located one mile east of the spot where the train had killed the other individual, and was the first specimen to be obtained by the writer that had a perfect skull. It was a young adult female, in full summer pelage, and measured in the flesh 218–37.5–26 mm. Then four days later, on April 6, 1916, Mr. Peters brought in to Mr. Brooking two more specimens, both in full summer pelage, which he had trapped in the same field in which he had secured the specimen on the second of April. The writer secured both of these specimens from Mr. Brooking and measured them in the flesh. One was an adult male and measured 237–39–28 mm., while the other

was an adult female and measured 225–38–25 mm. The skull of neither of these specimens was perfect, both being more or less broken posteriorly. Then on April 12, 1916, Mr. Lar. Meyers brought Mr. Brooking an immature female which had been killed by a dog in the same field as the three individuals just mentioned that had been taken by Mr. Peters. The writer secured this specimen also from Mr. Brooking. The measurements of the fresh skin, in which the length is estimated, are 200–29–21 mm. The skull of this specimen was also very imperfect and the skin was considerably torn. The taking of an adult male of *M. campestris* in the summer pelage attested to the plausibility of identifying Aughey's "Small Brown Weasel (*P. cicognanii*)" with that sex of the present species.

Following the taking of these five least weasels at Inland, Mr. Brooking kept a special lookout for additional specimens and secured evidence of the killing of at least twenty-nine others during the year 1916, all killed by boys and farmers in the vicinity of Inland. These are, briefly, as follows: On April 13, 1916, Mr. Joseph Brown killed a fine adult male least weasel which Mr. Brooking mounted for his collection. It measures, mounted, 242–38.5–24 mm. The writer has carefully studied this specimen and finds it has a marked white pencil in the tip of its tail. On April 16, another specimen, which the writer has not seen, was brought to Brooking and mounted and sold by him. It measured, Mr. Brooking writes, 235 mm. in total length and 37.5 mm. in length of tail, being, therefore, probably a male. On April 18, Mr. Lloyd Scherick took five specimens, four of which were only half grown, but none of these were obtained by Mr. Brooking, or preserved. On April 19, Mr. Frank Korgan killed two, neither of which were preserved. On April 21, Mr. H. Hendricks killed one and fed it to his cat. On April 25, Mr. Brooking secured another specimen, which the writer has not seen, from a farmer boy, and mounted and sold it. This specimen also had a well defined white pencil in the tail, according to Mr. Brooking, and measured 248 mm. in length; being the largest specimen as yet recorded, it was without doubt a male. During latter April nine more least weasels were reported taken near Inland by the following farmers: Ephraim Allen, Henry Hiatt, George Kramm, George Reed and Mr. Lee. On June 12 five were killed by Mr. Charles Green. On September 6 three were caught under a stack by a farmer living four miles southwest of Inland, but were not brought in to Mr. Brooking in time to save them. In fact, none of these last seventeen specimens were learned of in time to secure and preserve them, and in all cases the

TABLE OF MEASUREMENTS OF THE AMERICAN SUBSPECIES OF MUSTELA RIXOSA

(Type specimens designated by an asterisk)

Body measurements

LOCALITY	DATE	COLLECTOR	COLLECTION	SEX	TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT
					mm.	mm.	mm.
M. rixosa rixosa:							
Fort Smith, Mackenzie	6-21-1901	E. A. Preble	U.S.N.M. 115,812	♂	195	38.0	22.0
Fort Resolution, Mackenzie	7-13-1901	A. E. Preble	U.S.N.M.	♂	190	38.0	23.0
Osler, Saskatchewan*	7-15-1893	W. C. Colt	E. A. & O. Bangs 642	♀	181	31.0	20-22
Mouth Porcupine River, Alaska				♀	177.5	17.5	
Pembina, Minnesota		Chas. Cavileer	U.S.N.M. 435	♀?	171	21.0	
Tyonek, Alaska	9-19-1900	W. H. Osgood		♀	165	18.0	21.0
Didsbury, Alberta	4- 1-1906	Mitchell and Garrett	U.S.N.M. 159,420	♀	156	21.0	19.0
M. rixosa eskimo:							
Point Barrow, Alaska	6-25-1898	E. A. McIlhenny	Phil. Acad. 828	♂	230	31.0	22.0
Point Barrow, Alaska	6-21-1898	E. A. McIlhenny	Phil. Acad. 827	♂	204	28.0	20.0
Point Barrow, Alaska*	6-25-1898	E. A. McIlhenny	Phil. Acad. 848	♀	184	25.0	23.0
Point Barrow, Alaska	6-17-1898	E. A. McIlhenny	Phil. Acad. 826	♀	180	24.0	16.0
Point Barrow, Alaska	6-14-1898	E. A. McIlhenny	Phil. Acad. 829	♀	178	22.0	19.0
M. rixosa allegheniensis:							
Beallsville, Washington County, Pa.*	1885-1886	Robt. Hawkins	Phil. Acad. 6,195	♂?	199	19.0	20.0
Herman, Butler County, Pa.				♂?	188	33.0	20.5
Oberlin, Lorain County, Ohio	1-23-1904	Clarence Metcalf		♂	184	25.0	
Marshall, Madison County, N. C.	4-17-1916	M. L. Church	Biol. Survey	♀	183	31.0	21.0
Burlington, Racine County, Wis.	11-26-1906	E. J. Wehmhoff, Jr.	W.N.H.S. 1,363	♀	177	27.0	21.0
Leetsdale, Allegheny County, Pa.	4-25-1898	Wm. Seager	Carnegie Mus. 517-2	♀	175	22.0	20.0
Merrimac, Sauk County, Wis.	1-10-1906			♂	169	35.0	
Beallsville, Washington County, Pa.	1885-1886	Robt. Hawkins	S. N. Rhoads 4,279	♀?	145	22.0	20.0

M. rixosa campestris:							
Inland, Clay County, Nebr.	4–25–1916	Farmer	(?)	♂	248		
Chapman, Hamilton County, Nebr.	3– 1–1916	Fred Nickel	M. H. Swenk	♂	244	36.0	27.0
Inland, Clay County, Nebr.	4–13–1916	Jos. Brown	A. M. Brooking	♂	242	38.5	24.0
Inland Clay County, Nebr.	4– 6–1916	Wm. Peters	M. H. Swenk	♂	237	39.0	28.0
Inland, Clay County, Nebr.	4–16–1916	Farmer	(?)	♂?	235	37.5	
Inland, Clay County, Nebr.	3–22–1916	Section man	M. H. Swenk	♂	225	32.0	28.0
Inland, Clay County, Nebr.	4– 6–1916	Wm. Peters	M. H. Swenk	♀	225	38.0	25.0
Inland, Clay County, Nebr.	4– 2–1916	Wm. Peters	M. H. Swenk	♀	218	37.5	26.0
Inland, Clay County, Nebr.	7–21–1917	Farmer	(?)	♀	206	28.0	16.0
Page, Holt County, Nebr.	2– 1–1918	Farmer	M. H. Swenk	♀	201	40.0	20.5
Inland, Clay County, Nebr.	4–12–1916	Lar. Meyers	M. H. Swenk	♀	200	29.0	21.0
Inland, Clay County, Nebr.	3–10–1918	Farmer	M. H. Swenk	♀	200	28.0	22.0
Inland, Clay County, Nebr.	5–20–1917	Harvey Wilson	A. M. Brooking	♂	197	36.0	21.0
Inland, Clay County, Nebr.	8– 2–1917	Farmer	A. M. Brooking	♀	195	27.0	22.0
Glenville, Clay County, Nebr.	7– 7–1917	Farmer	?	♀	192	25.0	21.0
Norfolk, Madison County, Nebr.	8–1905	L. Sessions	M. H. Swenk	♀	187	28.0	22.0
Beemer, Cuming County, Nebr*.	4–18–1911	Grover Sharp	U.S.N.M. 171,490	♀	184	32.0	19.0
Trumbull, Clay County, Nebr.	11–1911	H. F. Warren	A. M. Brooking	♀	182	21.5	19.0

Cranial Measurements

LOCALITY	DATE	SEX	CONDYLO-BASAL LENGTH	BASILAR LENGTH (HENSEL)	ZYGOMATIC BREADTH	MASTOID BREADTH	INTER-ORBITAL CONSTRIC-TION	LENGTH OF MANDIBLE
			mm.	mm.	mm.	mm.	mm.	mm.
M. rixosa rixosa:								
Fort Smith, Mackenzie	6–21–1901	♂	31.9	29.8	15.8	15.0	5.6	15.4
Osler, Saskatchewan*	7–15–1893	♀		26.5	14.2	13.4	5.5	14.0
Tyonek, Alaska	9–19–1900	♀		27.5	14.0			
Didsbury, Alberta	4– 1–1906	♀			13.8		5.3	14.5
M. rixosa eskimo:								
Point Barrow, Alaska	6–25–1898	♂		35.0		17.0	9.0	
Point Barrow, Alaska*	6–25–1898	♀		29.0		15.4	8.0	
M. rixosa allegheniensis:								
Beallsville, Washington County, Pa.*	1885–1886	♂?		29.0	15.3	14.0	6.0	16.5
Burlington, Racine County, Wis	11–26–1906	♀	30.0		15.0	14.0	6.5	
Beallsville, Washington County, Pa	1885–1886	♀?		28.0	14.7			15.8
M. rixosa campestris:								
Inland, Clay County, Nebr	4– 6–1916	♂	36.7	34.5	18.0	16.0	7.5	19.0
Inland, Clay County, Nebr	3–22–1916	♂						18.0
Inland, Clay County, Nebr	4– 6–1916	♀	34.0		17.0	14.3	7.5	17.0
Inland, Clay County, Nebr	4– 2–1916	♀	34.0	31.5	16.0	15.2	7.0	17.2
Inland, Clay County, Nebr	5–20–1917	♂	33.5	31.5	18.0	16.0	6.9	16.8
Inland. Clay County, Nebr	4–12–1916	♀	31.7	29.5	15.5	14.5	5.8	15.0
Inland, Clay County, Nebr	3–10–1918	♀	30.8	29.0	14.7	14.5	5.8	15.5
Beemer, Cuming County, Nebr.*	4–18–1911	♀	30.9		15.0		6.2	

skulls had been smashed in killing the animals. Finally on September 9, a female least weasel was brought in to Mr. Brooking and was preserved by him.

The next year, 1917, Mr. Brooking continued his search for the least weasel, and was rewarded by learning of eight specimens, all of which he secured and preserved. On the morning of May 20 Mr. Harvey Wilson caught one in a low stubble field near Inland. This specimen is of a darker brown color above than any taken previously, and had perhaps a dozen white hairs in the tail pencil, but no black ones. It measured in the flesh 197–36–21 mm., and was sexed a male by Mr. Brooking, who mounted the skin for his collection (No. 2618a). He sent the writer the nearly perfect skull, which appears to be that of a male. On July 1 a nest with four young was found at Trumbull, Clay County. On July 7 a female specimen was taken near Glenville, Clay County. It measured in the flesh 192–25–21 mm. On July 21 another female was taken at Inland. It measured in the flesh 206–28–16 mm. On August 2 a third female was taken at Inland. It measured in the flesh 195–27–22 mm. These seven last mentioned specimens were all preserved by Mr. Brooking in alcohol.

In 1918, on the first day of February, Mr. Brooking had a least weasel in the immaculate white winter pelage sent to him from Page, Holt County. It was a female, and measured in the flesh 201–40–20.5 mm. The back of the skull was mutilated, and later it was lost by Mr. Brooking. On March 10 Mr. Brooking secured another female specimen at Inland, which shows the beginning of the brown pelage on the crown and nape and on a tiny spot on the rump. It measured in the flesh 200–28–22 mm., and the skull is perfect. The writer secured both of these specimens from Mr. Brooking. During the week of March 8 to 14, 1918, a least weasel was caught at Oshkosh, Garden County, according to Mr. Brooking. No least weasels were learned of in the years 1919 to 1923, inclusive, but in 1924, on May 23, another individual was killed near Inland. Unfortunately it was too badly decomposed to do anything with it when it reached Mr. Brooking. During 1925 the only least weasel learned of was one that was killed by a farmer on April 16, that was likewise too decomposed to save when it came into Mr. Brooking's hands.

All of this indicates that there is undoubtedly a colony of these little weasels in Clay County, Nebraska, and that they are locally common there. They frequent mouse runways, probably mostly of *Microtus*, and shallow burrows in the old stubble fields and on marshy ground.

Most of them are discovered by farmers through plowing them out on low ground during April and May, when they seem to be most active. Their diet seems to consist entirely of field mice.

Distributional records of *Mustela rixosa rixosa* are not plentiful in the literature. Baird's description (2, pp. 159–161) of the least weasel (*Putorius pusillus*) was based primarily on a mounted specimen (U. S. N. M., No. 435) from the extreme northwestern part of Minnesota, near Pembina, North Dakota; his second specimen, from Fort Steilacoom, Washington, (U. S. N. M., No. 2319) being, according to Bangs (3, p. 22), a young individual of the *cicognanii* group (undoubtedly the Puget Sound weasel, *M. streatori* Merriam). The name *pusillus*, used by Baird, had been applied to a New York specimen by DeKay in 1842, and was not applicable to this Minnesota specimen, as Baird himself thought was possibly the case (2, p. 160), and as was definitely shown to be true in 1896 by Bangs (3, pp. 4–5 and 22), when he identified the *pusillus* of DeKay with the small brown weasel (*M. cicognanii cicognanii*). In this same paper (3, pp. 21–22) Bangs gave the name *Putorius rixosus* to the *Putorius pusillus* of Baird (not of DeKay), using as the type a young adult female specimen collected at Osler, Saskatchewan, July 15, 1893, by W. C. Colt (No. 692, Coll. E. A. and O. Bangs).

Coues (8, pp. 104–105) mentioned a variety ("Var. 3") of his *Putorius vulgaris*, under which name he apparently included a mixture of *M. cicognanii* and *M. rixosa*, represented in the U. S. National Museum material before him by two skins from Canada (No. 4411 from Fort Resolution, Mackenzie, collected by R. Kennicott, and No. 4231 from Moose Factory, Ontario, collected by C. Drexler), which was to be distinguished by its very small size (about six inches long), short tail (tail vertebrae an inch or less long) and dark color. These two specimens are undoubtedly referable to *rixosa;* in fact Preble (14, p. 234) states that a skin of *P. rixosus*, "probably the one recorded by Coues under the name *Putorius vulgaris*," is now in the U. S. N. M., and Bangs (3, p. 22) definitely states that No. 4231, from Moose Factory, is his *P. rixosus*, and that there is a second specimen from that locality, taken by Drexler, in the Museum of Comparative Zoology (No. 5532). Bangs also mentions specimens in the U. S. National Museum from Fort Albany and Alaska. He states that all of the Alaska specimens except one (No. 13904 from the Upper Yukon River, collected by E. W. Nelson), are apparently females, and gives the cranial measurements of one adult from the mouth of the Porcupine River (3, p. 23).

Merriam (12, pp. 14–15) gives St. Michael, Alaska, and Sun River, Montana, as additional locality records of *P. rixosus*, but the least weasels of the former locality, in the Arctic Zone, are quite probably the subspecies *eskimo*. Osgood (13, pp. 69–70), however, records the taking of an adult female near Tyonek, Alaska, September 19, 1900, which he states differs but very slightly from the type of *P. rixosus* and shows no definite approach to subspecies *eskimo*, either in the color of the upper parts or in the size and shape of the skull. Preble (14, p. 234) records the taking of an immature but fully grown male specimen of *P. rixosus* at Fort Smith, Mackenzie, June 21, 1901, and of an adult male at Fort Resolution, Mackenzie, on July 13, 1901, by A. E. Preble, and mentions seeing tracks of what were probably this species at a number of points between Fort Norman and Fort Simpson in October, 1903. He also states that this weasel is probably to be found throughout the wooded part of the entire Athabaska—Mackenzie region. Cahn (5, p. 71) recorded *M. rixosa* as relatively common locally about Cedar Lake, Itasca County, Minnesota, where he saw two individuals on August 14, 1919.

In 1900 Stone (17, pp. 44–45) described *P. rixosus eskimo* as a subspecies of *P. rixosus* from a series of five specimens (2 males, 3 females), and an additional skull, collected at Point Barrow, Alaska, in June and July, 1898, by E. A. McIlhenny. This subspecies was chiefly characterized as duller colored than typical *rixosus*, with a shorter tail and a larger skull. He also records a specimen in the Philadelphia Academy collection obtained at Bethel, Alaska, by J. H. Romig, as belonging to the new subspecies. This locality is also in the Arctic Zone.

The following year (1901) Rhoads (15, pp. 751–754) described *Putorius allegheniensis* as a species allied to but distinct from *P. rixosus*, from three specimens from western Pennsylvania near Pittsburgh, two, including the (probable male) type (No. 6195, Acad. Nat. Sci. Phil. Coll.), having been taken at Beallsville, Washington County, about 1885 or 1886, by Robert Hawkins, and the third at Leetsdale, Allegheny County, April 25, 1898, by William Seager. This form was described as duller colored than *rixosus* and having the skull broader and flatter, with the interorbital space high, tumid, and constricted posteriorly. In 1904, Webster (25, pp. 827–828) reported the exhibiting of four specimens of *Putorius allegheniensis* at a meeting of the Biological Section of the Academy of Science and Arts of Pittsburgh, on February 2, 1904, one of them being an adult male that had been taken in a box trap a few days before near Pravo, Jefferson County,

Ohio, by a country boy. This was the seventh known specimen of this weasel, he reported, indicating that three additional specimens of *P. allegheniensis* had been taken around Pittsburgh between 1901 and 1904. In 1905, Wright (26, pp. 251–253) recorded the taking of an eighth specimen, near Oberlin, Lorain County, Ohio, January 23, 1904, by Clarence Metcalf. This specimen was chased out of a corn shock, and, though in the full white winter pelage, was accompanied by another individual that was wholly brown above. Mr. Wright also ventured the opinion that, unless some substantial difference was found, *P. allegheniensis* would need to be merged with *P. rixosus*.

In 1907, Ward (22, pp. 63–64) recorded the taking of a female specimen of the least weasel by E. J. Wehmhoff at Burlington, Racine County, Wisconsin, November 26, 1906, while it was in the act of killing a mole. Mr. Ward sent this specimen to Dr. C. H. Merriam, who identified it as *P. allegheniensis*, and further stated that he regarded *allegheniensis* as a subspecies of *P. rixosus*. Later, Ward (23, pp. 11–12, and 24, p. 82) recorded three additional Wisconsin specimens: a female captured at Sumpter, Sauk County, in November, 1902, a male taken at Merrimac, also in Sauk County, on January 10, 1906, and a female taken near Prescott, Pierce County, on March 6, 1911.[1] In 1912, Cory (7, pp. 378–379) reviewed these Wisconsin records and he also wrote *allegheniensis* as a subspecies of *rixosus*, indicating eastern Minnesota, northern Wisconsin and Michigan and a belt in southern Ontario as the probable area of intergradation between *rixosus* and *allegheniensis*. He also very plausibly identified the lesser weasel (*P. pusillus*) of Kennicott (11, p. 245), recorded as occuring in Indiana and northern Illinois, with this species. Recently, Henninger (9, p. 121) has written that *allegheniensis* has been frequently taken since 1905 in Mahoning County, Ohio, and also in Summit, Franklin and Darke counties in that state. He records especially a specimen taken at Wapakoneta, Auglaize County, in the winter of 1917–18, and a male in summer pelage taken near New Bremen, Auglaize County, on December 11, 1922. He draws attention to the fact that the gap in the known distribution of *rixosa* and *allegheniensis* is almost closed, and suggests the probable correctness of Wright's opinion that these are the same, or only subspecifically distinct. Very recently Church (6, p. 281) has

[1] The Field Museum of Natural History at Chicago has a specimen (No. 21,818) in the white winter pelage taken in Sumpter Township, Sauk County, Wisconsin, on December 17, 1911, by E. D. Ochsner, apparently constituting a fifth Wisconsin record.

recorded the taking of a female at Marshall, Madison County, North Carolina, on April 17, 1916.

It is evident, then, that there is no expressed question among mammalogists but that *eskimo* is a subspecies of *rixosa*, and it is also evident that the expressed opinion of mammalogists during the past twenty years is practically unanimous that *allegheniensis* is also a subspecies of *rixosa*. After considerable study, the writer has come to a similar conclusion regarding the relationship of *rixosa* and *campestris*. He first reached this conclusion through a study of the literature, and wrote *campestris* as a subspecies of *rixosa* in his state mammal list of 1915 (19, p. 854). Then in June, 1916, through the courtesy of the Biological Survey, he was able to directly compare his series of *campestris* with specimens, representing both sexes, of typical *rixosa* (♂, Fort Smith, Mackenzie, June 21, 1901, E. A. Preble, U. S. N. M., No. 115,812; ♀, Didsbury, Alberta, April 1, 1906, Mitchell and Garrett, U. S. N. M., No. 159, 420). This comparison confirmed his previous judgment, and he continued to write *campestris* as a subspecies of *rixosa* in his state mammal lists of 1918 (20, p. 411) and 1920 (21, p. 483).

These comparisons have made it obvious that, as compared with typical *M. rixosa*, *campestris* is a much larger animal throughout in both sexes, and the sexual disparity in size is more pronounced. Compared with the young adult male of *M. rixosa rixosa* mentioned above (Fort Smith, Mackenzie, June 21, 1901; U. S. N. M., 115, 812), *campestris* also exhibits a paler, less reddish brown dorsal coloration and a thinner pelage. The adult male *campestris* usually has white hairs in the tip of the tail, a feature it shares with *allegheniensis* but which is not mentioned anywhere for either typical *rixosa* or *eskimo*. The skull, however, exhibits the best characters. In typical *rixosa* the region between the glenoid fossa and the audital bulla is much inflated, so that its posterior edge is nearly in the same plane as the anterior edge of the audital bulla, while in the series of *campestris* skulls before the writer the audital bulla is abruptly much elevated. Also, in *campestris* the anterior portion of the braincase is distinctly depressed (while it is not depressed in typical *rixosa*), the whole braincase is narrower and less inflated than in typical *rixosa*, the rostrum is much more prominent and convex (flattish in typical *rixosa*), the interorbital constriction is much wider, and the palate is distinctly longer and narrower. The extent of white color on the feet and under parts is, in general, correlated with the age of the animal, and is not useful in

defining differences between the races, except possibly between individuals of the same age.

But these differences are, in the opinion of the writer, hardly such as to warrant a continued specific separation of *campestris* from *rixosa*, as they are but slightly greater than those exhibited by *eskimo* and *allegheniensis*, which, as has above been shown, are now currently regarded as subspecies of *M. rixosa*, but which, largely because of the paucity of available specimens, have not been absolutely proved to intergrade with *rixosa*. To be consistent, therefore, the writer proposes to regard *campestris* as a geographical race or subspecies of *M. rixosa*. These four forms of *M. rixosa* constitute a distinct group in the genus *Mustela*, the group of least weasels, definable as follows: Size very small to small, the total length not over 250 mm. in the male or 225 mm. in the female; tail very short, not over one-sixth of the total length, without a black tip or at most with a few black hairs at extreme tip, the terminal pencil very short and poorly developed.

With the series of specimens now before him, the writer is able to present a rather complete description of the several pelages and variations in *M. rixosa campestris*, considerably modifying the original diagnosis, as based upon a single female type specimen:

Color.—Adult in winter pelage (December to March): Entirely pure white, except sometimes for a very few black or blackish hairs at the extreme tip of the tail. *Adult in transition pelage* (March): Pure white, the nose, crown, circumorbital region, cheeks, neck above and a mid-dorsal stripe which is broad across the shoulders but narrows toward the tail, dark cinnamon brown (about Mars brown); the line of demarcation between the white and brown areas not sharp and regular, but with intermixed brown and white hairs marginally and with brown hairs appearing in small patches on the outer sides of the legs, especially about and below the heel; tail white below and toward the tip, cinnamon brown above at base and on a rapidly narrowing median line which becomes obsolete at two-thirds of the length of the tail, the extreme tip usually with a small tuft of black hairs. *Old adult in summer pelage* (April to August): Above uniform dark cinnamon brown (about Mars brown) becoming slightly darker on the face and nose; both lips, chin, throat and whole of under parts white, sometimes very faintly tinged with yellowish, the line of demarcation sharp, distinct and rather high up on the sides; inner side of fore legs and of hind legs above the heel white; fore feet white above and beneath; hind feet white above except for a brown band around ankles and mostly white beneath;

tail concolorous with upper parts, not distinctly penciled but usually with some very dark brown to blackish hairs, and in adult males frequently with some white hairs, intermixed at the tip. *Young adult in summer pelage* (April): Like the old adult but white on feet more restricted, largely confined to the toes above, especially on hind feet, the tail without white hairs at the tip. *Immature* (April): White of under parts much more restricted, the brown of the upper parts encroaching low on the sides and meeting to form a band across the middle of the belly, the legs wholly brown except the tips of the front toes, the tail without white hairs at the tip.

The valid characters and distribution of the four subspecies, so far as at present recorded in the literature or known to the writer, with measurements in millimeters, may be stated as follows:

Mustela rixosa rixosa (Bangs)

NORTHERN LEAST WEASEL

Coloration in summer a dark, rather bright, reddish brown (burnt umber to Vandyke brown); fur rather heavy. Size small. 5 ♀♀: L., 156–181 (170.1), T., 18–31 (21.7), H. F., 19–22 (20.5). 2 ♂♂: L., 190–195 (192.5), T., 38, H. F., 22–23 (22.5). Skull with the region between the audital bulla and glenoid fossa much inflated and the braincase not depressed anteriorly. 3 ♀♀: Basilar length, 26.5–27.5 (27), zygomatic breadth, 13.8–14.2 (14); mastoid breadth, 13.4; interorbital constriction, 5.3–5.5 (5.4); length of mandible, 14–14.5 (14.2). 1 ♂: Condylobasal length, 31.9; basilar length, 29.8; zygomatic breadth, 15.8; mastoid breadth, 15; interorbital constriction, 5.6; length of mandible, 15.4.

Type locality.—Osler, central Saskatchewan, Canada.

Geographic distribution.—Hudsonian, Canadian and Transition Zones of northwestern and north-central North America, from north-central Alaska (Mouth of the Porcupine River) and Cook Inlet (Tyonek), southern Mackenzie (Fort Reliance; Fort Simpson; Fort Resolution; Fort Smith), central Saskatchewan (Osler), and the western shore of James Bay (Fort Albany and Moose Factory, Ontario), south to northern Montana (Sun River) and northern Minnesota (Pembina; Clear Lake).

Mustela rixosa eskimo (Stone)

ARCTIC LEAST WEASEL

Coloration in summer averaging distinctly duller and paler than in *M. rixosa rixosa*, from reddish brown (between Prout's brown and walnut brown) to almost drab. Size of ♀ about as in *M. rixosa rixosa*. Size of ♂ somewhat larger than in the ♂ of *M. rixosa rixosa*, but tail and hind foot comparatively shorter. 3 ♀♀: L., 178–184 (180.6); T., 22–25 (23.6); H. F., 16–23 (19.3). 2 ♂♂: L., 204–230 (217); T., 28–31 (29.5); H. F., 20–22 (21). Skull decidedly larger and much broader interorbitally in both sexes than in *M. rixosa rixosa*. 1 ♀: Basilar length, 29;

mastoid breadth, 15.4; interorbital constriction, 8. 1 ♂: Basilar length, 35; mastoid breatdh, 17; interorbital constriction, 9.

Type locality.—Point Barrow, northern Alaska.

Geographic distribution.—Arctic Zone of northern and western Alaska, from the northern Arctic coast (Point Barrow) south coastwise to Norton Sound (Saint Michael) and Kuskokwim Bay (Bethel).

FIG. 1. GEOGRAPHICAL DISTRIBUTION OF THE SUBSPECIES OF MUSTELA RIXOSA

Mustela rixosa allegheniensis (Rhoads)

EASTERN LEAST WEASEL

Coloration in summer averaging slightly paler than in *M. rixosa rixosa* (about walnut brown), and fur thinner. Size of both sexes averaging about the same as in *M. rixosa rixosa*, the ♂ with the tail and hind foot comparatively shorter.

4 ♀♀: L., 145–183 (170); T., 22–31 (25.5); H. F., 20–21 (20.5). 4 probable ♂♂; L., 169–199 (185); T., 19–35 (29); H. F., 20–20.5 (20.2). Skull in general somewhat larger, distinctly broader interorbitally, and flatter than in *M. rixosa rixosa*. 2 ♀♀: Condylobasal length, 30; basilar length, 28; zygomatic breadth, 14.7–15 (14.8); mastoid breadth, 14; interorbital constriction, 6.5; length of mandible, 15.8. 1 probable ♂: Basilar length, 29; zygomatic breadth, 15.3; mastoid breadth, 14; interorbital constriction, 6; length of mandible, 16.5.

Type locality.—Beallsville, Washington County, southwestern Pennsylvania.

Geographic distribution.—Transition Zone and humid portion of Upper Austral Zone (Carolinian Faunal Area) from western Pennsylvania (Washington, Allegheny and Butler counties) through Ohio (Mahoning, Jefferson, Summitt, Lorain, Franklin, Auglaize and Darke counties) and probably northern Indiana and Illinois, to southern and western Wisconsin (Racine, Sauk and Pierce counties), south in the Alleghenies to western North Carolina (Madison County).

Mustela rixosa campestris (Jackson)

PRAIRIE LEAST WEASEL

Coloration in summer slightly paler than in *M. rixosa rixosa* (about Mars brown). Size largest, decidedly exceeding any of the preceding forms in both sexes. 11 ♀♀: L., 182–225 (199); T., 21.5–40 (31.2); H. F., 19–26 (21). 7 ♂♂: L., 197–248 (232.5); T., 32–39 (36.3), H. F., 21–28 (25.6). Skull large, about as in *M. rixosa eskimo*, but narrower interorbitally; the region between the audital bulla and glenoid fossa much less inflated and the braincase much more depressed anteriorly than in *M. rixosa rixosa*. 5 ♀♀: Condylobasal length, 30.8–34 (32.3); basilar length, 29–31.5 (30.3); zygomatic breadth, 14.7–17 (15.6); mastoid breadth, 14.3–15.2 (14.6), interorbital constriction, 6.2–7.5 (6.4); length of mandible, 15–17.2 (16.1). 3 ♂♂: Condylobasal length, 33.5–36.7 (35.1); basilar length, 31.5–34.5 (33); zygomatic breadth, 18; mastoid breadth, 16; interorbital constriction, 6.9–7.5 (7.2); length of mandible, 16.8–19 (17.9).

Type locality.—Beemer, Cuming County, east-central Nebraska.

Geographic distribution.—Upper Sonoran Faunal Area of Upper Austral Zone in eastern and central Nebraska (Cuming, Madison, Holt, Hamilton, Clay and Garden counties); exact limits of range unknown.

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University of Nebraska, Lincoln, Nebraska.

GENERAL NOTES

A CONJECTURE AS TO THE HABITS OF SOME WEST AMERICAN SHREWS

If taxonomic mammalogy is rather a rigid science, the trapping of mammals may possibly be an art, in which imagination does not constitute a *faux pas*.

Upon reading interesting communications concerning Merriam's shrew (*Sorex merriami*) and the gray shrew (*Notiosorex crawfordi*) in the JOURNAL OF MAMMALOGY, one notes that these extremely rare species are found in the territory of *Thomomys*, also a genus with atrophied optical faculties as a result of subterranean life. *Thomomys* is herbivorus, non-hibernating, aggressively fossorial to a degree that might unmask much subterranean insect life suitable for the diet of shrews, in moist, dark surroundings congenial to shrews, but in climates marked by dazzling sunlight and very little shade.

Would not patient planting of little shrew-traps in the burrows of pocket gophers bring some rare shrews literally to light? Most of the mammal trapping in the arid west has not been done with a view of perhaps getting one specimen of one rare species of shrew, regardless of anything else. Also the traps set underground for rodents have not been of the sort to hold diminutive shrews. Is it not possible that the above mentioned shrews and *Thomomys* work together?—MORRIS M. GREEN, *Ardmore, Pennsylvania*.

A SKUNK ENTRAPPED BY NATURE

In January of 1923 the son of a neighbor reported the strange entrapment of a skunk which he had killed. When found it was caught in a bunch of dead weeds, where it was firmly held by the tail. The roadside weeds standing in that spot were mainly asters and Spanish needles.—ALTHEA R. SHERMAN, *National, Iowa*.

PERIODICITY IN THE CALLING OF A CHIPMUNK

Acknowledgment for the identification of a particular member of *Tamias striatus griseus* is due to Dr. Dayton Stoner. That it was the same chipmunk in each instance of observation seems quite certain from the fact that aside from this one individual I have seen within the term of thirty years but one other chipmunk in this prairie location. Although it is only two miles from the woods, where chipmunks are quite common, these animals seldom wander so far from their native haunts.

A few times in the autumn of 1919 a chipmunk was seen on our home place. It seems quite probable that the same animal appeared in the following spring. Migration records for the last days of March show that the first bird arrivals were a little in advance of average dates, but April weather proved cold and backward. It was on the first, fourteenth, and twenty-seventh of April that the chipmunk's alling was heard. These intervals of thirteen days between callings, days on which the chipmunk was seen, but not heard, possibly may hold interest for those studying the periodicity in mating among chipmunks or among their near relatives.

The weather was rainy in the forenoon of April 1, clear on the fourteenth, and unsettled on that of the twenty-seventh. Beginning early in the morning the

chipmunk "sang" almost constantly during the forenoon of each of these days and until 2:30 p.m. of the fourteenth. Three degrees of loudness in his calling were noted, the lowest scarcely heard by one of dull hearing, while the loudest notes were distinctly heard by the observer, when a hundred and thirty yards away. At times the noise resembled the exhaust puffs of an engine. The performer's throat and cheeks rose and fell like the sides of bellows, and his entire body shook as if responding to a powerful emetic. Once while calling softly, he put his forepaws together and licked them, then rubbed them over his face. The presence of an observer apparently did not disturb him.

After a time he found entrance into the wood room where stood the garbage kettle containing apple peelings and partly decayed apples of which he ate. His quickness in locating food in a new place was exemplified one day when having frightened him from the kettle it was taken seventy-five feet away to the opposite side of the house and emptied. During the absence of the kettle he returned and set up a great chattering. Twenty minutes later he had found the apples in the new place and had resumed his meal.—ALTHEA R. SHERMAN, *National, Iowa.*

FOX SQUIRRELS' NESTS IN A BARN

The western fox squirrel (*Sciurus niger rufiventer*), common in our woodlands, wanders out on our prairies more frequently than it is welcome. In mid-summer it sometimes builds nests in our treetops, but in two instances a fox squirrel has made its bed for sleeping purposes in a box placed for flickers inside of our barn. The depth of the box is nineteen inches and its other dimensions are approximately eight by thirteen inches. It is one of seven boxes inside the barn placed back of holes drilled by flickers; no hint of their presence is obtainable from without. In the top of each is a peep-hole through which the bird or animal within can be watched. The first squirrel nest was made in August, 1920, the second about the same season in 1925. Although the squirrel was seen in its nest several times in each year, unfortunately it was not seen carrying the nest material of walnut leaves. According to circumstantial evidence, in its journey from the only walnut tree with branches overhanging the barn roof to the box the squirrel travelled the length of the barn roof, forty-four feet, then jumped down about four feet to a slender perch, a half-inch in diameter, close to the entrance hole.—ALTHEA R. SHERMAN, *National, Iowa.*

DWARF MARMOTS

In the spring of 1907, when collecting in northwestern Colorado, I took a couple of park marmots, *Marmota flaviventer luteola*, which seemed to be dwarfs or runts. The first was taken April 17, near Sulphur Springs, Grand County, at about 7900 feet. It was a female and measured: total length, 455 mm.; tail vertebrae, 135; hind foot, 75. The second, a male, was taken on Sheephorn Pass, Summit County, 8000 feet, May 21, and its measurements were: total length, 438; tail vertebrae, 133; hind foot, 75. Sheephorn Pass is about 25 miles southwesterly from Sulphur Springs. Other marmots taken at the same localities and at the same time varied in total length from 570 to 631; tail vertebrae, 162 to 220; hind foot, 83 to 88.

These two small specimens were very evidently not young of the year. It was

too early in the season for that. Their pelage in both color and texture was that of adults, and the skin had the toughness of that of adults.

July 13, 1907, we captured at Mud Springs, Garfield County, 8850 feet, a female and two of her young. These latter measured: total length, 434 and 441; tail vertebrae, 129 and 137; hind foot, 67 and 74. The smaller was a female, the larger a male. It will be noted that they were nearly the size of the smaller of the two dwarfs. The mother measured, total length, 620; tail verebrae, 173; hind foot, 75. It should be stated that these last belonged to a different subspecies, *M. f. warreni*, but the breeding seasons of both are identical.

The Sulphur Springs dwarf is very similar in color to a full-sized specimen from the same locality, the variation being no more than individual. The Sheephorn Pass dwarf is rather lighter in color than the other, but this also is covered by individual variation. The pelage of both seems to feel somewhat softer than that of the larger skins, but the difference is only a slight one. In the juvenile from Mud Springs, however, the coat is thin and the guard hairs rather scattering, while the underfur has nothing like the length and density of that of the dwarfs. Neither is the tail as bushy as in those animals.

A juvenile male taken at 12,500 feet on Mount Lincoln, Park County, Colorado, September 28, 1914, had moulted into its winter coat, with long, dense underfur, but the guard hairs, while thick, are short. This specimen measured: total length, 470; tail vertebrae, 146; hind foot, 75.

An examination of the skulls of the dwarfs shows the sutures well closed, partaking much more of the characters of adults than of juveniles. In fact they are very similar in this respect to a large male taken at Sulphur Springs. The sutures in the skull of a juvenile from Mud Springs are much more open.

Ever since I captured these two dwarfs they have been more or less of a puzzle to me. That is, I could not account for their small size. They were obviously not young animals, were perfectly formed, and appeared to be healthy. The fine condition of the fur shows it. Why did they remain small? Were they members of unusually late litters which did not attain full growth before hibernating? The Mount Lincoln specimen hints at the possibility of this. Taken September 28 at an altitude where the marmots hole up any time after October 1, it was only about three-quarters grown, and would have had to remain out a considerable time before attaining full size. If, however, instead of being collected, it had gone into winter quarters at once, it probably would have made no more growth during the winter, and would have emerged in April a dwarf like the two which were the inspiration of this note.—Edward R. Warren, *Roosevelt Wild Life Forest Experiment Station, Syracuse, New York, and 1511 Wood Ave., Colorado Springs, Colorado.*

A HORN OF THE PRONG-HORN ANTELOPE (ANTILOCAPRA AMERICANA) FOUND AT MOLINE, ILLINOIS

The present attention being given the vanishing prong-horn antelope and the somewhat tragic interest attaching to all information pertaining to it move me to report that in the spring of 1918 I unearthed an antelope horn on the outskirts of the city of Moline, Illinois, in the patch of timberland locally known as Brooks' Woods (1st Street and 8th Avenue).

The discovery suggests that possibly the former range of the prong-horn extended farther east than does the area to which authorities now limit it. In his article, "The Prong-Horn," published in a former number of the JOURNAL OF MAMMALOGY (May, 1922; vol. 3, no. 2, p. 90), M. P. Skinner says, "In former days the prong-horn ranged from central Iowa to the Pacific Coast and from the Saskatchewan River to the interior of Mexico, most generally on the open plains or in broad valleys. There is no record of it being east of the Mississippi in historic times, no bones found even in the old Indian mounds, and no traditions among any of the eastern Indians."

The horn was found in the middle of a broad stream-valley, where it had lain buried under about eighteen inches of alluvium. I caught sight of the tip of it protruding from the stream bank, where it had been exposed by recent rain erosion. It was a full-sized horn, both prongs were intact, and its surface was still hard and fairly undecayed.

It is possible that this horn may have been brought here from some other locality by Indians; I have found much evidence that this valley was once with them a favorite camping site. However, Indian flints, pottery fragments, and other artifacts occur so near the surface that I can often find them by simply peeling off the sod. The horn was embedded in alluvium more than a foot below the flint-bearing horizon. Further, most of the flints are found at two localities, one about a quarter of a mile up stream from where the horn was discovered, the other not quite that distance downstream from it. There is no indication that the horn had ever been used in any way as an implement.

The fact that there were no bones associated with the horn offers slight support to the hypothesis that it was brought here from elsewhere. However, it may be a shed horn. Further, the stream which deposited the alluvium on top of it may also have carried it some distance and here lodged it. The isolation of the horn might also be explained on the basis of its superior resistance to decay as compared with the rest of the skeleton.

The finding of this one horn is far from conclusive evidence that the prong-horn once ranged east of the Mississippi River, but it at least raises the question of whether this may not have been the case. If any further evidence bearing on the subject is available, it should be reported.—F. M. FRYXELL, *Augustana College, Rock Island, Illinois.*

MOUNTAIN GOAT (OREAMNOS MONTANUS MISSOULAE) NOT FOUND IN WYOMING

During my thirty years work in the Yellowstone National Park, I have heard occasional very dim rumors of mountain goats in the surrounding mountains. Finally I became interested, especially as I had never seen any sign of the species either in the park itself or in the state of Wyoming, and carried on an investigation. I talked to many officials, guides, rangers, hunters, and men interested in wild animals but not once could I obtain a clue to a definite occurrence. True, Wyoming once had a game law protecting wild goats but it seems to have been enacted without any real inquiry as to whether the animal really existed within the state.

Howard Eaton told me he had never heard of wild goats in the state. John Duncan, a former game warden, remembered the law already mentioned but

said he had never heard of the animal itself in the state, and thought the law had been enacted without any inquiry but with the intention of protecting the animal should any be found later. Harry Trischman, first assistant chief ranger of Yellowstone National Park, had never seen nor heard of a goat either in the park or in the Teton Mountains. Raymond Little, former Yellowstone Park scout and ranger, had never seen nor heard of a white goat in the park or vicinity. Many other parties in whom I had confidence, made the same or similar statements.

Upon looking up the literature on the country, I found that most authorities were silent and ignored the subject entirely. Among these was Merritt Cary who did not mention the animal in his Life Zone Investigations in Wyoming. Vernon Bailey in his article on Wild Animals in the Rules and Regulations of the Yellowstone National Park for 1920 says: "Mountain goats have been reported from the Teton Mountains and Yellowstone Park, but there is no authentic record of their occurrence nearer to the park than the Bitterroot Mountains in western Montana and the Lost River Mountains in Idaho." Arnold Hague in American Big-Game Hunting, Boone and Crockett Club, says: "all the large game animals of the northern Rocky Mountains are known in the park except the white goat and the caribou." Owen Wister, in Caspar Whitney's Musk-ox, Bison, Sheep and Goat says he has "never talked with any hunter who had seen him [the white goat] in Wyoming."—M. P. SKINNER, *Roosevelt Wild Life Forest Experiment Station, Syracuse, New York.*

RECENT LITERATURE

Newsom, William Monypeny. WHITETAILED DEER. New York: Charles Scribner's Sons. 12 mo, pp. xii + 288, pls. 31 (unnumbered), text figs. Cloth, $3.00. August 27, 1926.

If book-learning can assist in a knowledge of methods in the wild, deer-hunters should welcome this work on the white-tailed deer. Fully four-fifths of the book is devoted to tracking, hunting, equipment, and other matters directly concerned. Most of this is clearly and interestingly presented by the writer, who takes the reader on a fictitious hunt with him and explains details as the hunt progresses. Considerable stress is laid upon the points on a deer upon which to hold the rifle-sights in order to assure a clean kill, for which the author deserves much commendation.

Throughout the book are scattered nuggets of original information on habits and life-history, but the major portion along these lines is assembled in two chapters (VIII and IX), partly compiled from Caton and other sources. A brief chapter (VII) is chiefly devoted to an attempt at witty sarcasm at the expense of the mammalian taxonomist dubbed "Long Whiskered Old Party," in which the author so confuses facts that he is successful in his humor, in producing a comedy of errors. This, however, may be ignored since the author modestly states in the preface: "I am not an authority, and no doubt have made many mistakes."—HARTLEY H. T. JACKSON.

Rowley, John. TAXIDERMY AND MUSEUM EXHIBITION. New York and London: D. Appleton and Company. 8vo, pp. 331, pl. 29, text figs. 20. Cloth, $7.50. 1925.

In taxidermy, as in other mechanical arts, great improvement in technique has been effected during the past thirty years. As intimated in the author's preface, the secrecy and jealousy which formerly characterized this work has given place to free exchange of the fruits of experience. This has resulted in an improvement in the quality of output which tends to keep pace with demands corresponding with the general advance in education. And in this improvement of methods and results no one is more directly responsible than the author of this newest work on taxidermy, a man whose long experience includes notable service in several of our leading museums.

The title of the book indicates that its purpose aims further than the mere preparation of the specimen, and this impression is found to be fully justified. Specimens must be collected before they are mounted, and the first chapter therefore logically deals with various methods of capture and the initial preservation of specimens, especially birds and mammals. These instructions include specific advice on the selection, care, and use of guns, traps, poisons, and tools, and the treatment of the specimen in the field.

A second chapter deals mainly with the equipment and materials needed in fitting up a workroom suitable for the mounting and installation of various groups of vertebrates, and includes descriptions of tools, preserving powders and solutions, and the materials needed for accessories. This is followed by chapters on casting, mounting birds, mammals, fishes, reptiles, and crustaceans, the collecting, preparation and mounting of skeletons, the preservation and manufacture of accessories, and the final result of all this preparatory work—the finished group and its exhibition.

The chapter on preservation and mounting of the skins of mammals occupies about one-third of the book, this full treatment being justified by the great variety of form and structure found in this group, and the consequent diversity of method necessary. We note with satisfaction that the book gives more details regarding the preparation of study specimens than is usually the case in such works.

With the excellent photographs which illustrate the various steps in skinning small mammals (and the same is true in the case of birds) the average amateur student should be able to master the rudiments of the work without difficulty. These instructions, in fact, are the best substitute we have seen for the ideal method of teaching, that is, direct instruction by a trained worker.

In the chapter on the preparation and assembling of accessories, the subject is treated with a wealth of detail never before attempted in a work of this kind. In this chapter, and indeed throughout the book, credit is given, with a liberality that is refreshing, to the various persons whose patience and inventive ability have served to bring the art of taxidermy to its present state of forwardness.

In treating the important subject of exhibition the author draws on his long experience to point out the ends to be sought in planning a museum building and its furniture.

This book should be in the possession of every student who aspires to do the best work possible in this useful field, and we venture to add that there will be

found few experienced workers who can not profit by a thorough acquaintance with its contents.—EDWARD A. PREBLE.

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COMMENT AND NEWS

The following, from a report of a lecture by Capt. Keith Caldwell, Acting Game Warden of Kenya Colony, is extracted from the "East African Standard," of August 28, 1926: "There were three kinds of people who killed game—the man who killed because animals were doing damage to his crops; the sportsman; and the man who shot game for profit. It was the third-named who was the great danger. . . . . What the lecturer termed the profit killer was on the increase today. A number of people were taking to game killing as a living, and the damage they were doing was incalculable. . . . . Every loophole put into the [game] ordinance to assist the genuine crop cultivator had been taken wrongful advantage of by the profit killers. . . . . Elephants with 100-lb. tusks were getting rarer and rarer. . . . . The quickest and most certain way of wiping animals off the face of the earth was to commercialize their trophies. . . . . The general scarcity of game in many of the uncultivated, uninhabited areas must strike anyone on *safari* nowadays, and the lecturer attributed that scarcity largely to the increase in the ranks of the profit killers. The country was now faced with a very definite choice—either to put the profit killers out of business or to let all the game go.

"Italian Somaliland was getting away with it was impossible to say how many thousand pounds of [Kenya] ivory, and if there were some sort of international agreement to prevent that sort of thing, Kenya would be much richer by the retention of elephants. . . . . A powerful international agreement with a powerful international organization was needed to stop indiscriminate traffic in big game trophies. He hoped this was a question with which the League of Nations would occupy itself! 'If you make ivory a government monopoly, and have a proper agreement under the League of Nations, with someone appointed to bring abuses to light, then there will be some hope of saving the game of Africa from being commercialized. Once the big game is gone, it can never be replaced; it is gone absolutely and forever.'"

The corresponding secretary requests that all who desire a symposium at the next annual meeting advise him of the fact, and suggest a subject that would be of most interest.

At the Berlin Museum, Dr. H. Pohle has been made head of the Mammal Department, and Dr. Ernst Schwarz has been granted a research fellowship by the Government, which enables him to devote his entire time to research.

The Ninth International Congress of Zoology in session at Monaco in March, 1913, decided to hold the tenth meeting in 1916 at Budapest, Hungary, under the presidency of Dr. G. Horváth, of the Hungarian National Museum. The war made this impossible and the meeting was postponed. The president now announces that the Tenth International Congress of Zoology will meet in Budapest, Hungary, on September 4 to 9, 1927, and invites all zoologists and friends of zoology to attend. The program will be issued before the end of this year and sent to those interested.

In the last number of this JOURNAL mention was made of the status of wisents in Europe at the close of the year 1924. During 1925 twelve calves were born, of which nine were bulls and three cows, the largest number of births since the Wisent Society was organized. There have been several deaths so that at the close of 1925 the number of living wisents, exclusive of the Caucasian herd, was 69 (36 males and 33 females), an increase of three over the previous year.

Prof. D. José Maria Gallegos, naturalist and explorer of the Dirección de Estudios Biológicos of the Republic of Mexico, died from a complication of swamp fever and gangrene while on official duty in Yucatan, on September 24, 1925. Professor Gallegos was born November 26, 1883, at Calvillo, Aguascalientes. He spent nine years in biological exploration in Sonora, Sinaloa, and Lower California, and collected many specimens for the Mexican government. Senor Gallegos was one of the most prominent and progressive scientists of his native land.

Frank Morley Woodruff, curator of the Chicago Academy of Sciences, died in Chicago, July 21, 1926. Born at Leavenworth, Kansas, July 16, 1867, he became interested in natural history as a boy, and at the age of seventeen made a collecting trip for birds and mammals to western Maryland. Although known primarily as an ornithologist, he had an interest in mammals as exemplified in the groups installed under his direction at the Chicago Academy.

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